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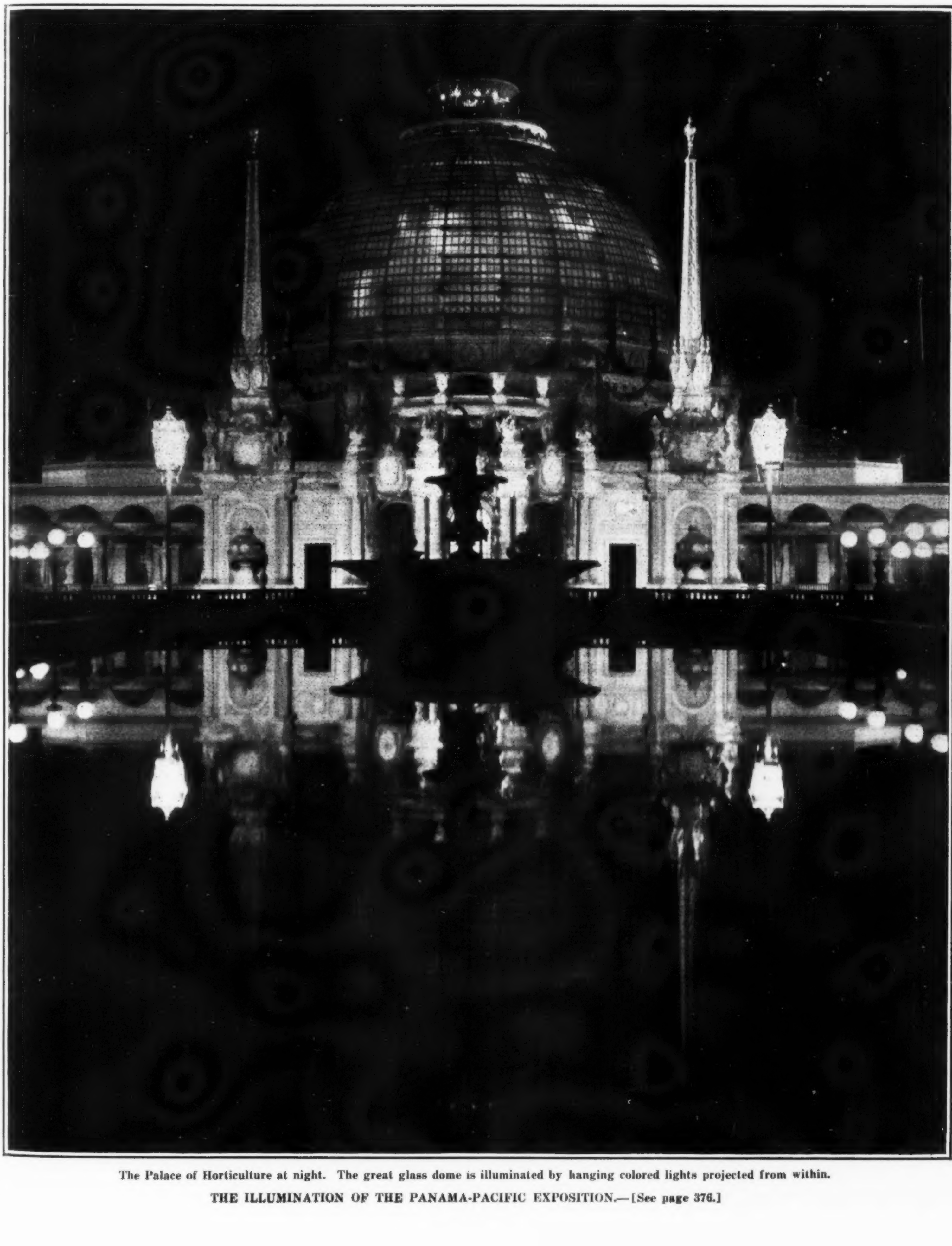

The Palace of Horticulture at night. The great glass dome is illuminated by hanging colored lights projected from within.

THE ILLUMINATION OF THE PANAMA-PACIFIC EXPOSITION.—[See page 376.]

The Future of Science

What New Discoveries Are Possible and Which Will Be Most Desirable

In December, 1913, many French and a few foreign men of science were invited by *Le Temps*, of Paris, to indicate the discoveries possible in the actual state of science, which they regarded as most useful, and also those which were most eagerly awaited in various branches of science.

Summaries of the most interesting replies are given below:

Prof. Emile Picard: This distinguished mathematician reminds his questioner that very useful discoveries do not always win contemporary appreciation. The Greek geometers, whose work still affects astronomy and navigation, were not famous in their day, and Sadi Carnot's classical memoir on "the motive power of fire," was ignored for 20 years. How, then, can we predict which new discoveries will be most useful?

In applied science the circumstances are somewhat different, and there can be no doubt that the discoveries most impatiently awaited are those which pertain to disease and old age. The fountain of youth and vaccines for all diseases are universally desired.

In moral science, a remedy for social and international hatred, which appears to increase daily, would be a fine discovery.

Prof. Yves Delage: This eminent biologist, whose sight has been almost destroyed by his work on artificial fertilization of sea urchins' eggs, regards the adaptation of species to their conditions of existence as the great riddle of biology. This undeniable fact seems explicable only by the heredity of individual modifications due to environment, but this heredity has not been demonstrated and apparently does not exist. The problem, therefore, is to discover either the hidden way by which these modifications are transmitted to descendants, or some method of evolution that can dispense with such transmission. Many attempts have been made in both directions, but no satisfying solution has been reached.

Another desideratum is convincing proof of the generally accepted hypothesis that the chromosomes maintain their individuality through generations of cells and organisms and that their substance is the sole material substratum of cell properties and hereditary characters.

Prof. E. B. Baillaud, director of the Paris Observatory: Prof. Bailland indicates several promising astronomical researches.

The Swedish astronomer Sundmann has solved the celebrated problem of three bodies, but his solution seems numerically inapplicable. It may be possible to find other solutions applicable to the complete study of planetary motions.

Solar radiation possesses the highest interest, because it affects meteorology, agriculture, hygiene and all vital phenomena. So much has been learned, in the past 20 years, concerning the variations of solar radiation that it is not too rash to predict that the study will be completed within a few decades.

The constitution of the stellar universe presents a fascinating problem. The monumental star catalogues undertaken last century are nearing completion and the distribution of the stars over the celestial vault is very accurately known. By studying the parallax, proper motion and brightness of a great number of stars we can determine their distribution in space, and learn whether the visible stellar universe is of finite or infinite extent. Results full of promise have been obtained in the past 15 years.

Not less interesting is the quest of the elements that fill interstellar space, which contains swarms of meteors, countless stars surrounded by gaseous atmospheres, and nebulæ as big as constellations. The earth receives only a few minerals from the meteors that it encounters, but we know not what may be added to its atmosphere by the nebulæ that it traverses.

Exact knowledge of the form and dimensions of the earth, and their variations, is also desirable. It is now possible to undertake a study of gravity, longitudes, latitudes and their variations that may explain the causes of these variations and the constitution of the earth itself.

Prof. Svante Arrhenius: The famous Swedish astronomical physicist who devised a new cosmogony and a theory of interstellar dissemination of organic germs by the force of radiation (panspermy) briefly expresses his opinion that now, after the enormous recent advances in physics and chemistry, the time has come to solve, with the aid of the knowledge thus acquired, those biological and medical problems that are most important for the future of humanity.

Dr. E. Grasset expresses, still more briefly, a similar opinion: that tuberculosis and cancer are the two great problems, the solution of which is universally desired.

Prof. Charles Moureu: This well-known chemist sent a very long contribution, inspired by his diligent study of radioactivity and the rare gases of thermal springs. After describing radioactive disintegration and the electron theory of atoms, and conceding that no method of accelerating, retarding or otherwise affecting radioactive changes has yet been discovered, he asks if we shall be content to remain in this state of impotence, and cites, in illustration, the artificial synthesis of many organic compounds, for the formation of which a mysterious "vital force" was formerly deemed necessary.

Two problems are presented: to stimulate the spontaneous disintegration of the instable radioactive atoms, and to destroy the stability of the atoms of other elements. All attempts to influence radioactive phenomena by means of very high or low temperatures have failed. Perhaps the employment of very high or low pressures would be more successful. The known radioactive elements are the elements of highest atomic weight, and the current theories of the evolution of matter and worlds assume that heavier and heavier atoms come successively into being as the pressure increases.

On the other hand, electric discharges in highly rarefied gases produce electrified particles which can come only from atomic disintegration. Röntgen rays and radium rays produce analogous results in the ionization of gases. Electrified particles are emitted, also, by negatively electrified metals exposed to ultraviolet rays. One of these ways may lead to the goal.

Magnetic force, however, seems peculiarly fit for the task of destroying the electro-magnetic equilibrium of the atom. The maximum magnetic force yet developed, 50,000 gausses, has proven insufficient, but a force ten times as great might shatter the structure and produce new atoms of known or unknown kinds from the fragments. The vast possibilities thus suggested lead Prof. Moureu into speculations which it would be futile to follow.

Prof. Armand Gautier: Prof. Gautier, whose researches on nutrition, toxins and the living cell have become classical, likewise regards the capture of radioactive energy as the most important object. A gramme of radium generates in one hour sufficient heat to raise the temperature of one gramme of water from the freezing to the boiling point. Hence, as the life of radium is 2,500 years, one gramme must possess more than a million calories of convertible energy.

If this is energy of rotation the capture of part of it does not seem impossible. When two rapidly spinning billiard balls come gently into contact their energy of rotation is suddenly converted into energy of translation, and they are projected with great velocity in opposite directions. It may be possible to realize this with atoms.

Sir Edwin Ray Lankester: This eminent English physician replied that scientific researches should not be undertaken for utilitarian ends, but should be inspired solely by the desire to increase human knowledge. The exploitation of science by industry and the self-advertisement of so-called scientific benefactors do not further the progress of science. In order to know which researches are most desirable it is necessary to study the question systematically. The future of science is a secret that can be understood only by those who approach it by the way of study.

Charles Nordmann: This young astronomer of the Paris Observatory, the inventor of an ingenious instrument for measuring star temperatures, begins by discriminating between two meanings of the word "useful." The most useful discoveries, in the customary sense, would be discoveries leading to the conquest of tuberculosis, cancer and other diseases, or to the industrial exploitations of natural sources of energy, including solar radiation, atomic energy and tidal energy, which probably will be the first to be utilized.

In another sense, however, nothing seems more useful or more desirable than the solution of problems concerning the nature of things. For example, are all vital phenomena reducible to physical and chemical processes? An affirmative answer would not supplant mysticism by pure materialism, for physical and chemical forces are mysterious in themselves, but it would entail the possibility of producing artificially, in the fulness of time, living creatures endowed with any desired qualities, physical and mental.

Another problem of acute interest concerns the relations between matter and ether, and the way of escape from the labyrinth of contradictions to which the principle of relativity leads.

And nothing, perhaps, would be more useful or more important for the future of mankind than the discovery of unfailing methods of selecting and educating those children who are capable of becoming geniuses.

Prof. Henry Le Chatelier thinks that researches on the intimate constitution of matter are desired by the majority of chemists, but declares his own preference for the general diffusion of the methods, as distinguished from the results of science, and the application of these methods to everyday affairs. He cites the scientific organization of metallurgical work achieved by the American engineer F. W. Taylor, through the application of scientific methods to the psychology of the workers (a system which Prof. Le Chatelier has introduced in France), and also mentions "The New Housekeeping," a book on the scientific organization of the home, written by an American woman, Mrs. Christine Fredericks.

Prof. Pierre Puiseux: This distinguished selenographer of the Paris Observatory, after stating that the most useful and desirable discoveries are those most beset with difficulties, indicates two lines of research that seem at once important and promising. One aims at the capture of atomic energy, the other at the artificial reproduction of stellar spectra.

Although 12,000 of the 20,000 dark lines in the spectra of the sun and most stars do not correspond to bright lines in laboratory spectra of known elements, there is good reason to believe that they are due to known elements, in physical conditions that we have not yet been able to imitate. This belief has become stronger since we have learned that light is modified by electric and magnetic influences, and that metallic vapors can become fluorescent, and emit waves differing in length from the incident waves. A group of stellar lines that had long been an enigma has recently been reproduced in the laboratory with a mixture of hydrogen and helium.

But there are stars, and especially nebulæ, which give a spectrum composed of bright lines, only a few of which correspond to the lines of hydrogen. The distribution of the lines indicates that they may be due to a single element, of very complex atomic constitution. In the laboratory this may reveal itself either as a new element, or as a known element in a peculiar state. The discovery would greatly clarify our notions of the structure and history of nebulæ.

Prof. Gustave Le Bon: Prof. Le Bon devotes the greater part of his letter to his claim of priority in the conception of spontaneous atomic disintegration. In his opinion, however, the possibility of utilizing the energy liberated by the artificial disintegration of atoms, if this could be accomplished, is doubtful, because it is to be feared that the expenditure of an equal amount of energy would be required to effect the liberation. For the same reason the transmutation of elements possesses no practical value, although its theoretical interest is very great.

Prof. J. Hadamard: This eminent mathematician replies that it is very difficult to predict the ways in which science will advance, and absurd to choose between them. The tendency toward the unification of science is the essential thing.

Dr. Arnold Netter: Dr. Netter, who introduced in France the Wassermann-Flexner serum for cerebrospinal meningitis, predicts great progress in various departments of medicine and surgery, including serum therapy, organo therapy, transfusion of blood, suture of organs, and the study of the effects of mineral agents, including those which, like arsenic, iodine and fluorine, are found in the body in infinitesimal quantities. The great advances made in these fields in recent years have been due to the collaboration of men of all nations. This collaboration will continue and will create a foundation for universal peace.

Prof. Gaucher: Dr. Gaucher, likewise confining his reply to the medical field, says that every effort should be devoted to the conquest of tuberculosis, the most formidable of all human maladies.

Prince Albert of Monaco: Prince Albert, the creator of the new science of oceanography, regards as especially desirable such discoveries in palaeontology as will throw light upon the history of humanity and will make anthropology a guide in philosophy and ethics. If human judgment were based on exact knowledge of the place which human history occupies in the history of the organic world, the barbarism that still remains in communities professing to be civilized would be more easily conquered. When it shall have been proved that the human race necessarily follows the path traced by the forces which produce its central faculties, we shall know better how to accomplish social progress.

The preservation of living species is as important as the collection and preservation of remains of extinct species.

Prof. Gaston Bonnier: Prof. Bonnier, who has made extensive researches on the changes produced in plants by changes in their environment, emphasizes the importance of the problem of evolution of species. All

naturalists of the present day are transformists, in that they believe that a species can be transformed into a different species by external or internal influences, but they do not agree in regard to the mechanism of the transformation, and the fact is not proved. Experiments with plants have already given results that appear to confirm Lamark's view, that the forms and functions of organs are modified chiefly by changes in external conditions of life.

Prof. Paul Sabatier: Prof. Sabatier, who in 1912 shared with Prof. Gregnard the Nobel prize for chemistry, hopes for the speedy discovery or production of large quantities of radioactive substances.

Prof. Samuel Pozzi: Dr. Pozzi replies that exact knowledge of the cause of cancer is a most urgent desideratum. Neither the parasitic nor the non-parasitic theory has been proved conclusively, although the latter is perhaps supported by the stronger evidence, including results obtained recently by Dr. Pozzi.

The discovery of the parasite would soon be followed by the production of a diagnostic serum which would lead to very early operation. It might even be possible to produce a curative serum, that would diminish the extent and danger of the operation, which would still be necessary in Dr. Pozzi's opinion.

If the disease is not parasitic, knowledge of the conditions that promote the growth of cancer cells would suggest methods of preventing the disease, or, at least, of arresting or retarding its progress.

Prof. Emile Borel: Emile Borel, professor of the theory of functions at the Sorbonne, and an adept in the theory of probabilities, thinks that the scientific revolution has already been inaugurated by the application of the statistical method, notably to radioactive changes, which we can explain in no other manner. The sudden explosion of a single one of a multitude of radium atoms is governed by the known laws of probability. The point of departure for the science of the twentieth century is the principle that the most immutable laws are based on chance. The explanation of phenomena will consist in their reduction to very numerous elementary actions, regulated by statistical laws, as the pressure of gases is explained in the kinetic theory of gases. The most attractive problem is the statistical explanation of universal gravitation. When the statistical method has taken its proper place in mechanics and physics, it will be possible to apply it with advantage to biological and social problems. It is already recognized that the mysteries of hereditary can be explained in no other way. This transformation of science will influence our conception of knowledge. The dogmatic value of a law like that of Newton will give place to the practical demonstration of the improbability of miracles, and statistical certainty will be substituted for logical certainty.

Prof. E. C. Pickering, of Harvard: This eminent American astronomer regards as the most important of astronomical discoveries the determination of the numbers of stars of different colors and degrees of brightness, for the purpose of finding their distribution in space and fixing the limits—of these are limits—of the stellar universe. Determinations of parallax and proper motion would be equally interesting.

Correspondence

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Safe and Unsafe Oxy-Acetylene Generators

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

In a recent issue of the SUPPLEMENT there was published a description of how to make an oxy-acetylene welding outfit, and while the writer is undoubtedly a clever mechanic, it is evident that there are many peculiarities of acetylene and facts in relation to its practical use that he is unacquainted with. As a consequence, the apparatus which he describes contains elements of serious danger, and it is of a form that meets the disapproval of all experts and experienced men.

In view of the above a few facts in relation to acetylene may be not only of interest, but particularly valuable to those contemplating the use of welding apparatus.

After the acetylene industry, which for the first few years gave especial attention to illumination, had developed the lighting generator to a point where it was so well safe-guarded that the National Board of Fire Underwriters pronounced acetylene illumination safer than the systems which it usually replaced, the great possibilities of oxy-acetylene autogenous welding became known.

Any new utilization of chemical elements brings to the surface new problems to be solved, and the rapid development of the oxy-acetylene welding process brought to the acetylene industry the necessity of a good many changes, among them the development of modifications in the system of generation. The details of the rapid adaptation of the industry to this new field only have interest to the general public, in so far as it may now be said that this field is as well covered as regards safety as the systems used for illumination.

The simplicity of the reaction between calcium carbide and water in the early days tempted many who are not engineers or chemists to bring about this reaction, and because they got illumination as a result, they did not realize that acetylene, like any other gas, must be properly controlled or it will cause trouble. So in the oxy-acetylene welding field engineers and mechanics not familiar with acetylene sought to simplify the systems of generation, and this has led to an epidemic of plans and specifications for simple generators, put forth in good faith by their originators, but hazardous in the extreme because the necessary safeguards, which long experience has demonstrated to be necessary, were entirely lacking.

The form which has seemed to be most attractive to these amateur designers has been the pressure generator, the basic idea being the mixture of carbide and water in such a way as to produce the gas under pressure, utilizing this pressure at the blow-pipe. Kitchen boilers are a favorite means of storing acetylene under pressure, or storing oxygen under pressure, or, many times, both in the same apparatus. The absence in the general markets of apparatus of this kind has led those uninitiated to believe that no one else has thought of this plan, and that a large field was open to the inventor who discovered it. The facts are that almost everyone in the industry has at some time passed through the stage of evolution where this idea has occurred to them, and the fact that no apparatus of this kind is to be had in the market should be a warning instead of an encouragement.

Acetylene under pressure changes its physical nature. After it reaches 15 pounds to the square inch, it gradually becomes more and more apt to dissociate without the addition of oxygen. The word "dissociate" as applied to acetylene means that the acetylene, which is composed of carbon and hydrogen, will, under certain circumstances, separate and cease to be acetylene but become carbon in the form of lampblack and hydrogen in the form of a gas. In doing so, it will give off considerable quantities of heat. The atoms therefore fly apart with explosive violence. If acetylene is not under pressure, the molecule which dissociates is too far removed from its neighbor to cause the next molecule to break up, but once you compress acetylene, the molecules come close enough together so that one molecule sets off the next, so that the whole mass goes instantly and with great violence. All that is needed to start the explosion is a temperature of 539 deg. Fahr. or above this. One of the best illustrations of this is a row of dominos; assuming that you set your dominos three inches apart and knock over the first, the second one will not fall, the row of dominos will stand except the one which has fallen over, but if you bring the dominos close enough together so that one falling hits the next, the whole row goes off. So it is with acetylene—so long as the acetylene pressure is less than 15 pounds to the square inch, it may be subjected to high temperatures without dissociating except molecule by molecule, but if you compress above 15 pounds to the square inch, the danger point has been attained, and the more you compress the more dangerous it becomes. It is for this reason that free acetylene above 15 pounds to the square inch is forbidden all over the world.

The moment that this point is understood, it becomes apparent that what is known as the pressure generator would not be permitted for use by any authorities, municipal, State or insurance, if all the inspectors understood the matter. It is sufficiently understood so that these generators have never attained any large sale, and there is really no market for them that can be made profitable by anybody. There are a few concerns in the country who are pushing these generators. They are made not only for the oxy-acetylene industry, but they are used to create a pressure in acetylene which may be utilized in charging automobile cylinders. The use of pressure generators for this purpose has been followed by a record of death and destruction which should be sufficient warning. Nevertheless, there are certain people who, knowing the circumstances, still persist in endeavoring to feist pressure generators upon the local garage man or some inexperienced persons who may be induced to organize a little company for the purpose of filling automobile cylinders or welding. Widespread attention should be called by the scientific journals to the facts in the case and mechanics and others who are experimenting with acetylene should be warned not to undertake the compression of acetylene by any means, above 15 pounds to the square inch.

Numerous manufacturers are making generators working up to but not over 15 pounds pressure, which have passed the National Board of Fire Underwriters. These are properly safeguarded, and there is no reason why those desiring to enter the oxy-acetylene field should not secure a proper generator rather than risk their lives by using experimental systems of generation, which may be economical, but which contain inherent hazards which have not yet been overcome.

A. CRESSY MORRISON,
Secretary International Acetylene Association.

A Curious Property of Numbers

WRITE any number of three digits, of which the first is greater than the last, say 170
Interchange the first and last digits 071
Subtract
——
099
Considering this difference to be also a number of three digits, interchange its first and last digits... 990
Add this number to the preceding.
——
The result will always be 1089

Another example:

582
285
——
297
792
——
1089

This rule is a particular instance of a general rule, obtained from the above by putting "two or more" for "three," the result being for a number of

2 digits $9 \times 11 = 9 \times 11 \times 1 = 99 \times 1 = 99$
3 digits $9 \times 121 = 9 \times 11 \times 11 = 99 \times 11 = 1089$
4 digits $9 \times 1221 = 9 \times 11 \times 111 = 99 \times 111 = 10989$
5 digits $9 \times 12221 = 9 \times 11 \times 1111 = 99 \times 1111 = 109989$

For a number of n digits ($n>1$) the result is 9 times a number of n digits, of which the first and last are 1's and the others, if there are any, are 2's; or 99 times a number of $n-1$ digits, all of which are 1's; or, if $n=2$, the result is 99, if $n>2$, the result is a number of $n+1$ digits, of which the first two are 1, 0, the last two 8, 9, and the others, if there are any, are all 9's. Also, if $n=3$, we note that the result is $3^2 \times 11^2$, or 33^2.

We will prove the rule for the case when $n=3$. The general proof is similar.

Let m be the given number and a, b, c its digits, of which $a>c$.

Then $m=a\times10^2+b\times10+c$.

Let m' be the number obtained from m by interchanging the first and last digits.

Then $m'=c\times10^2+b\times10+a$.

Now when we proceed to subtract in the units column, since $a>c$, we add 10 units to the minuend and, to balance this, add 1 ten to the subtrahend, so that

$$m+10=a\times10^2+b\times10+(10+c)$$

and $$m^1+10=c\times10^2+(b+1)\times10+a.$$

Then as we cannot take $b+1$ tens from b tens, we add 10 tens to the minuend and 1 hundred to the subtrahend, so that now we have

$$m+10+100=a\times10^2+(10+b)\times10+(10+c)$$

and $$m'+10+100=(c+1)\times10^2+(b+1)\times10+a.$$

Subtracting we get

$$m-m'=[(a-c)-1]\times10^2+9\times10+[10-(a-c)]$$

Since a and c are digits and $a>c$,

$$0\leqq c<a\leqq 9$$

Hence $$1\leqq a-c\leqq 9$$

Hence $$0\leqq(a-c)-1\leqq 8 \text{ and } 1\leqq 10-(a-c)\leqq 9$$

Therefore $(a-c)-1$, 9, and $10-(a-c)$ are the digits of the difference $m-m'$.

Set $r=(a-c)-1$ and $s=10-(a-c)$

Then $r+s=9$ and $m-m'=r\times10^2+9\times10+s$

Hence $(m-m')'=s\times10^2+9\times10+r$

Therefore

$$\begin{aligned}(m-m')+(m-m')' &= (r+s)\times10^2+2\times9\times10+(s+r)\\ &=9\times10^2+2\times9\times10+9\\ &=9(1\times10^2+2\times10+1)\\ &=9\times121\end{aligned}$$

In a two or three figure number interchanging the first and last digits is the same as reversing the order of all the digits. This is not so in general for a number of more than three figures.

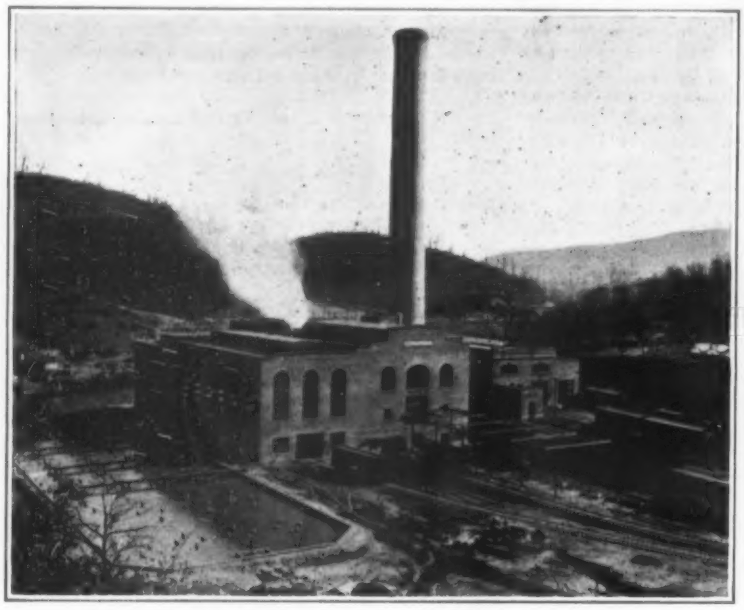
For such numbers, however, special rules can easily be worked out for the result of an operation like that explained above in which we reverse the order of all the digits instead of merely interchanging the first and last digits.

For example, starting with a four figure number $a\ b\ c\ d$,
if $a>d$ and $b>c$, the result is 10890;
if $a>d$ and $b<c$, the result is 9999.
Starting with a five figure number $a\ b\ c\ d\ e$,
if $a>e$ and $b>d$, the result is 109890;
if $a>e$ and $b<d$, the result is 99099.

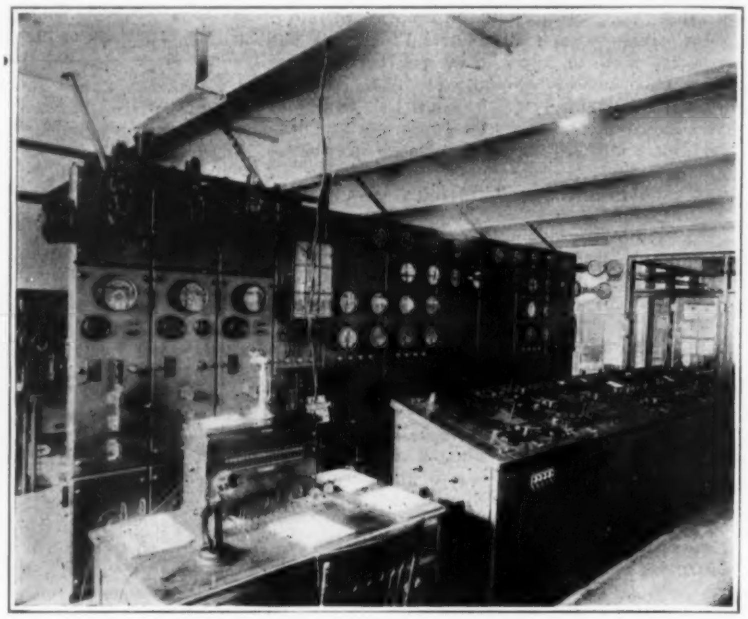
JOSEPH BOWDEN.

Adelphi College.

Many of the railway lines between France and Belgium intersect the trenches, and regular trains cannot be run in those localities; but the Germans have utilized these lines by bringing in cars operated by storage batteries and operating them singly to remove the wounded from the battle front, and to bring back supplies.



The power and inspection houses at Bluestone.



Instruments and levers that control the power.

Electrification of the Elkhorn Grade

A Notable Power Equipment on the Norfolk & Western Railway

The electrified section of the Norfolk and Western Railway, known as the Elkhorn Grade, is located on the main line in West Virginia, about 105 miles west of Roanoke, and extends from Bluefield to Vivian, a distance of about 30 miles. The section is double track throughout, except in the Elkhorn Tunnel, which is single track. There is also a large amount of third track, or passing sidings and branches into the coal workings and yard trackage.

The grades on the line are heavy, varying from 1.0 per cent at the west end to 1.5 to 2 per cent up the grade, to and through the summit tunnel, a distance of about 10 miles; thence the line descends on a 2.5 per cent grade for about a mile and then rises again at the ruling rate of about 0.25 per cent for 10.5 miles and finally up a 1.22 per cent grade for three miles into Bluefield, the easterly end of the division. Fully 60 per cent of the line is on curves, the maximum being about 12 degrees.

The electrification of this section of the railway is primarily for the purpose of collecting from the main sidings and yards in the coal fields the entire eastbound coal tonnage, and transporting it up the grades and over the summit to the classification yard at Bluefield, the division point of the railway. From Bluefield, after classification, it is shipped east to the various destination points. All coal traffic originates west of Flat Top.

There are numerous colliery sidings throughout the coal fields and the electric service includes the collection of loaded cars or trains from these sidings on the eastbound trip and the delivery of empties on the return trip. It will thus be seen that the electrified section is practically a local switching and short haul division between the coal fields and Bluefield, operated to a large extent independently of the other traffic of the main division. In addition to the heavy tonnage coal train service, however, through merchandise freight and passenger traffic over the electrified section, which is still handled by steam road engines, is also handled in part by electric engines which are used as pushers or helpers up the grades.

A condition favorable to electric traction is the fact that trains may be despatched at fairly uniform intervals throughout the day and thus desirable loading conditions on the power system are obtained and at the same time the full service is handled with a moderate number of locomotives, each making a number of round trips per day.

The purpose of the company in electrifying this section is to increase the capacity of the railway by materially reducing the time required to handle trains and to provide a more economical and efficient service over the heavy grades. To this end the heavy freight trains are handled with electric locomotives at a running speed up the grades of 14 miles per hour as compared with about 7½ miles per hour under steam operation; and a further saving in time is also effected by the elimination of the delays steam trains have heretofore occasioned by occupying the tracks while the engines take on coal and water, one at a time, at the several coal and water stations on the grade. The effect of increased speed is especially marked at the single track Elkhorn Tunnel 3,000 feet long on 1.5 per cent grade, where on account of ventilation requirements, it has been necessary under steam operation to reduce the speed up grade in the tunnel to about 6 miles per hour. This requires about seven minutes to clear the block, whereas under electric operation this movement is made in about three minutes.

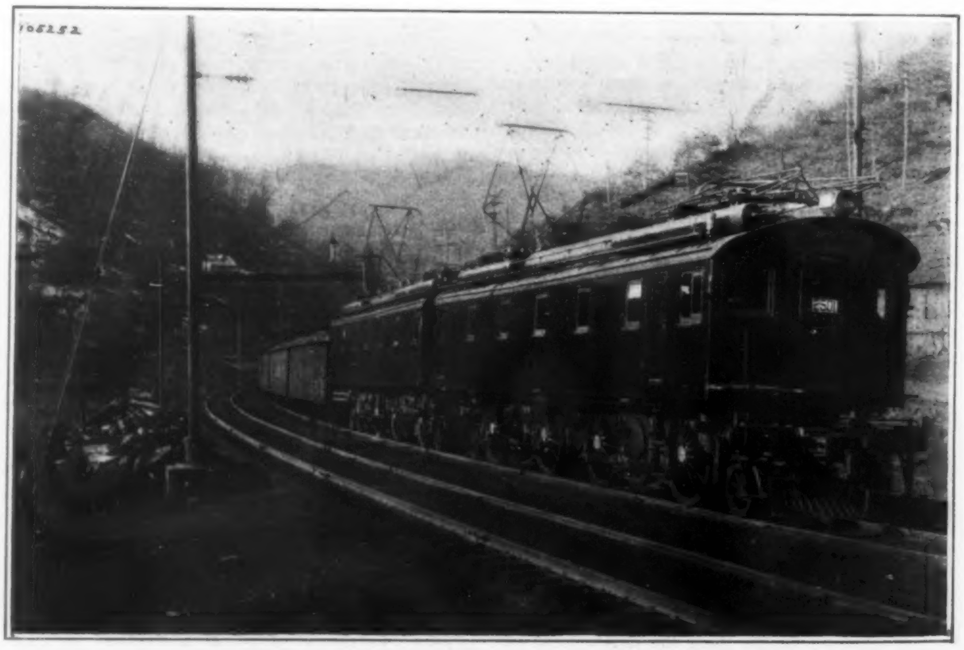
The heavy coal trains, known as "tonnage trains," handled in this service weigh 3,250 tons and have formerly been handled up the grade by three steam locomotives, two of these, a road engine and helper, one at each end of the train, being used over the entire section, and the third, at the rear, serving as a pusher up the 1.5 and 2 per cent grades, this pusher being cut off at the summit. These steam engines are of the highly developed heavy Mallet type fitted with mechanical stokers and superheaters. Under electric operation a single road engine is used over the division and a second electric engine is used as a pusher up the 1.5 and 2 per cent grades. Thus it will be seen that one electric engine takes the place of two Mallets over the division or two electric engines take the place of three Mallets up the grades and handle the train at approximately double the steam speed. The speed at which the electric locomotives handle the trains on the 0.4 per cent grade between Cooper and Graham is 28 miles per hour.

The electrical installation has been laid out and power plant, locomotives and other equipment provided for handling 20 tonnage trains, or 65,000 tons, a day eastbound over the division and provision has been made for additional traffic when required. The number of these tonnage trains handled per day at present is about twelve, in addition to which pusher and helper service is provided for through freight and passenger trains.

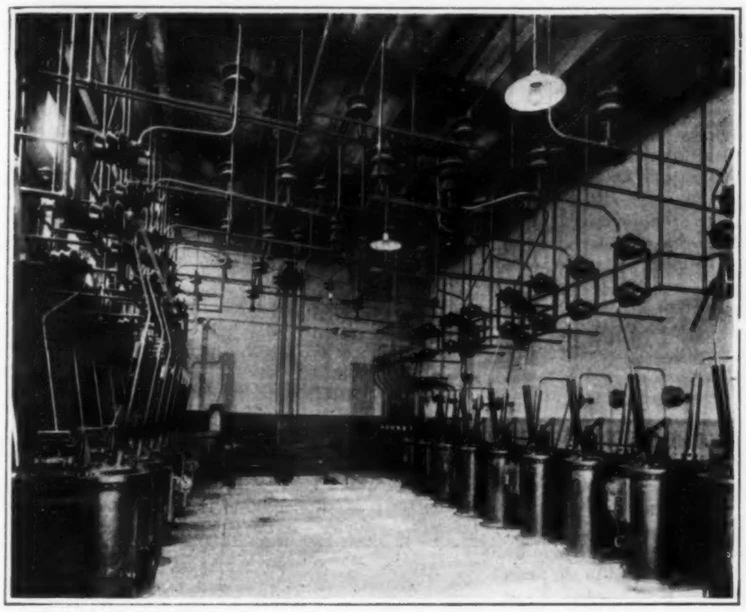
Power is generated in single phase at 25 cycles and 11,000 volts; is stepped up to 44,000 volts for distribution, and is delivered to the line at 11,000 volts, single phase, from suitably located sub-stations fitted with static transformers. The locomotives, however, are unique in that they are equipped with phase converters, which, in connection with the main step-down transformers on the locomotive, transform the single-phase power of the trolley to three-phase power for use in the three-phase induction type traction motors. Thus, while retaining all the advantages of high voltage single-phase distribution and collection, the advantages of three-phase induction motors for these heavy traction mountain grade conditions are also secured.

Another characteristic feature of the installation is the fact that as the result of the use of traction motors of the polyphase induction type it is feasible without the use of additional or complicated apparatus and devices to utilize the locomotives for electrically holding or braking the trains at constant speed while descending grades. This utilizes the energy in the moving train descending the grade to drive the motors as generators and thus return energy to the line.

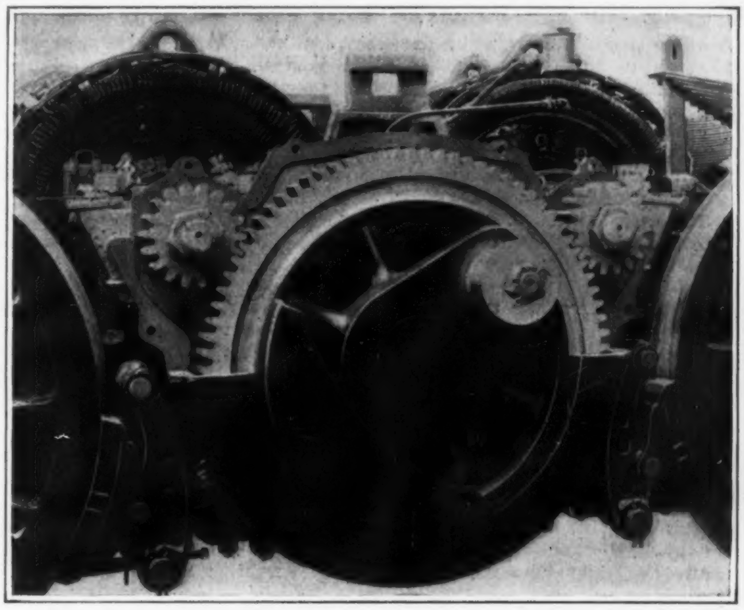
This kind of electric braking or "regeneration" has been much discussed and often proposed both in this country and abroad but with the exception of the Giovi line in Italy this feature has not been utilized in any extensive commercial electric railway operation. Even on the



One of the 270-ton, 5,000 horse-power electric locomotives.



The electrical switches.



Locomotive motors and gearing.

Giovi line the train weights do not exceed 400 tons and it is evident, therefore, that this is the first instance where the use of this form of electric braking has ever been attempted for heavy freight train service such as obtains on American railroads. On the Elkhorn Grade the conditions are such that the full advantages of this form of braking can be secured as the trains are very heavy, the grades severe and speeds are relatively high. This feature of the installation has proven highly satisfactory, the heaviest trains being handled down the mountain grades with a single engine at a uniform speed of about 15 miles per hour with the utmost ease, the air brakes being held in reserve for bringing the train to a standstill when required. This results in a large reduction in the wear on the cars and locomotives generally. While the above is the principal advantage obtained from regenerative braking, there is also some saving in power due to the return of energy to the line, which is available for augmenting the power house in supplying power to other trains if there is a demand for such power at the time.

Next to the electric locomotives, the most interesting feature of the electrification is probably the catenary line construction. In designing this feature of the installation, the engineers had uppermost in mind the two important requirements of reliability of service and low cost of maintenance. An effort has been made to secure the maximum degree of flexibility and freedom from hard spots at the contact wire so as to avoid rapid deterioration and frequent breakages and failures.

In working out the design on these lines the catenary system has taken the form of single catenary with an auxiliary messenger wire above the trolley, one main hanger being provided for every two intermediate connections between auxiliary and trolley on tangents. On curves the angularity of the hangers provided the necessary flexibility, the auxiliary messenger and trolley wire being both connected to the hanger at the same point.

Great care has been taken also to provide ample clearance between every live part and adjacent grounded structures and as a rule this clearance is maintained at not less than 18 inches so as to avoid the danger of birds or foreign materials causing a short circuit. The same principle applies in the tunnels, the insulators are, however, placed off to the side and out of the direct blast from locomotive stacks and here two 44,000 volt transmission line insulators in series are used in all cases between live points and ground.

The line supports are light bridges made of tubular poles and Bethlehem "H" section crossbeams, and the structures are guyed on the outside of curves to resist the curve pull by means of two heavy guy rods secured in concrete anchorages. At signal bridges the signals and catenary systems are supported on structural bridges which consist of latticed posts carrying shallow plate girders which form as little obstruction to the view of signals as possible and are easily painted and maintained. The same type of bridge is used on curves where it is impossible to provide guys at the outside of the curve.

In addition to the direct advantages and savings resulting from the electric train service the railway has taken advantage of the presence of an adequate power supply at net cost of generation for the operation of various auxiliary plants. Thus a large steam pumping station at Bluestone for the water supply for steam locomotives has been shut down and the pumping is done at the electric power station located nearby, and the fans for ventilating the Elkhorn Tunnel will now be driven by electric motors.

The layout and design of the entire installation was worked out in all details by Gibbs and Hill, engineers for the company. All construction, excepting the power house and inspection buildings and some of the power station equipment, was carried out by a specially organized railroad force under the supervision of the engineers.

The power station is of the usual type using steam boilers and steam turbines as the prime movers. It is located at Bluestone on the Bluestone river about 11 miles west of Bluefield mainly for the reason that this is almost the only available source of water for boiler feed and condensing purposes in the district and the railway company had already constructed a dam and reservoir here for the water supply for its steam locomotives.

The main structure is about 135 feet by 158 feet with a 52 feet by 33 feet extension at the northeast corner, and contains, besides extensive power and auxiliary plants, the usual switching outfits, and accommodations for the operating staff, the extension containing the transformers.

The boiler plant comprises ten Stirling type water tube boilers, designed for a working pressure of 225 pounds gage and equipped with superheaters capable of superheating the steam 150 deg. Fahr. at normal rating. Each boiler is fitted with an underfeed stoker.

The initial power equipment consists of three horizontal turbines of the Westinghouse-Parsons impulse reaction double flow type rated at 10,000 kilowatts with steam at 190 pounds, superheated 150 deg. Fahr. and 28½ inch vacuum when running at 1,500 revolutions per minute, and governed by an oil relay mechanism for operating the steam valves.

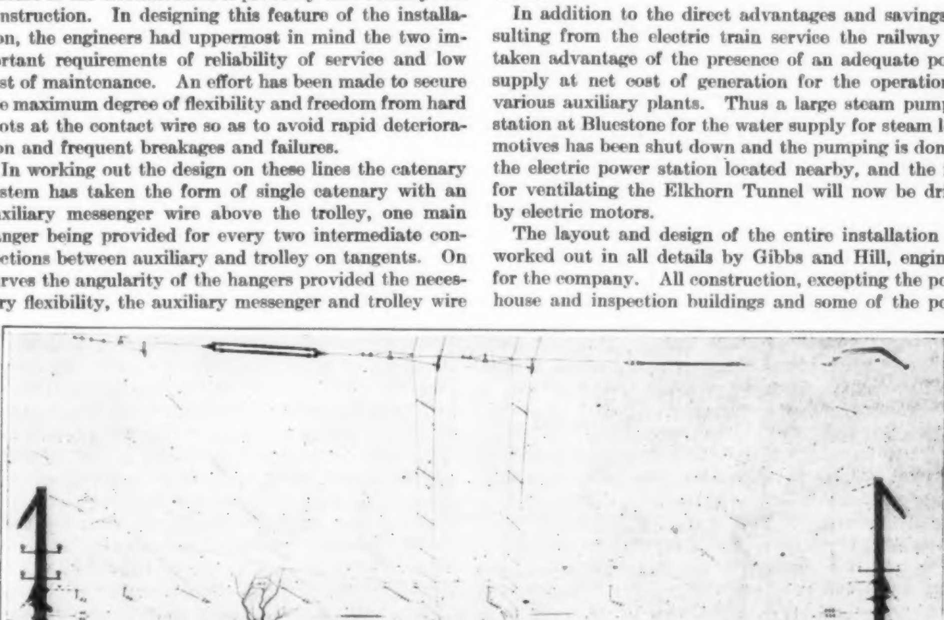
The main turbo-generators are of the Westinghouse type having a rating of 10,000 kilowatts at 80 per cent power factor, 11,000 volts, 25 cycles, single phase. At this rating, the generators are specified to operate for 24 hours with a rise in temperature not exceeding 60 deg. Cent. above the temperature of the cooling air.

Excess regenerated power returned to the power house at no load passes to the 11,000 volt bus and through the various transformers back to the generators if the generators are running under very light load or no load. If no other load were provided, the regenerated power would reverse the generators and operate them as motors. To prevent this a loading device consisting of electrodes immersed in the intake canal and controlled by suitable switches is provided.

The operation of the switches is made automatic by means of a group of relays and magnetic switches, current transformers, etc, so connected as to give the following results:

When the amount of excess regenerated power reaches say 300 K.V.A. the closing relays throw in one water rheostat on the 11,000 volt bus. As soon as the regenerated power exceeds the capacity of one water rheostat by 300 K.V.A. another closing relay throws the second water rheostat in on the 11,000 volt bus. The difference between the amount of excess regenerated power and the capacity of the water rheostats in service is made up by the generators.

When the excess regenerated power has become reduced to zero with one rheostat in service all of the rheostat load being supplied by the generators one of the tripping relays trips the circuit breakers which cuts the rheostat off the 11,000 volt bus. With two rheostats in service, when the excess regenerated power drops to 2,000 K.V.A. one of the relays opens the breaker which was closed first and cuts one rheostat out of service. The other rheostat remains in until the excess regenerated power drops to zero when it, too, is cut out of service.



View of a freight yard, illustrating system of electric distribution.

Each rheostat consists of a steel cone carrying a lead from the circuit breakers, and a fixed ingot iron plate located at the bottom of the intake canal, and grounded to a copper plate bedded in the earth outside of the canal. The power dissipating capacity is adjusted by varying the distance between the cone and the iron plate. The cone is raised or lowered in the water of the canal by means of a hand-operated winch and cable carried on a steel bracket across the canal.

The traffic on the electrified section is handled by twelve 270-ton Baldwin-Westinghouse locomotives, each consisting of two 135-ton units or halves.

It is necessary in handling heavy trains on mountain grades to have a part of the motive power at the rear of the train in order to avoid excessive strains on the draught rigging of the cars. In this case the power is divided equally between the two ends of the train and the trains are of such great length in this mountainous country that there is difficulty of signaling from one locomotive to the other and thus the locomotives are subject to treatment which would be considered impossible in ordinary service. For instance, it is not unusual for the rear locomotive on receiving a starting signal to stand still for a minute or more exerting full tractive effort in an effort to start the train before the head locomotive has got into full action. Also in stopping a train the head engine shuts off power and the brakes are applied while the rear engine keeps pushing the train until it comes to a standstill. This would require some very careful handling with the ordinary locomotive, but the electric is designed to meet just these severe requirements of the service and that without involving special manipulation. In meeting these conditions the rugged construction of the three-phase induction motor being free from commutators, the liquid rheostats are of the greatest importance. The liquid rheostat not only gives the smoothest possible gradations of tractive effort, but the latent heat of steam makes it possible without difficulty to dissipate the large amount of heat generated in the rheostat in meeting this severe requirement.

Each unit has two main trucks connected by a Mallet type hinge, and each main truck has two driving axles included in a rigid wheel base with a radial two-wheel leading truck. The bumping and pulling stresses are transmitted through the main truck frames and through twin draught rigging mounted on the main trucks at each end of the unit. The cab is of the box type and is supported on the main truck entirely by spring cushioned friction plates, there being no weight on the center pins, which serve only to maintain the cab in its proper position on the trucks. An engineer's compartment is provided at one end of each unit, the two units being so coupled as to provide for operation from either end of the locomotive. Each locomotive is equipped with eight traction motors of the three-phase induction type, with wound secondaries for four pole and eight pole operation.

There are two running speeds, 14 and 28 miles per hour. In starting, resistance is inserted in the secondary circuit of the motor by means of a liquid rheostat. For the 14 miles per hour speed all motors are connected in parallel, having the eight pole motor combination; and for the 28 mile per hour speed they are also connected in parallel but with the four pole motor combination. The locomotives are equipped with unit switch type of control and arranged for the simultaneous operation of the two units from the control end of either.

The control equipment is built for handling alternating current, which is collected from the 11,000 volt line by the pantagraph trolleys. This current is fed to the main transformers through an oil type circuit breaker. A phase converter is connected to the low tension side of the transformer and operates constantly when the locomotive is in service. To its extended shaft are coupled a blower for cooling the motors, transformers and other parts, and, through a clutch the air compressor.

The two trolleys mounted on the roof of each unit, are of the well known pantagraph type, but are unique in that they have been arranged so that if necessary they may be fitted with end horns which will automatically fold in when the pantagraph is lowered by the tunnel trolley wire. In this way the unusually wide sliding surface will accommodate itself to the restricted tunnel clearances. The trolley is raised and held in contact with the overhead wire by springs and is lowered by compressed air. When locked down the trolley can only be released by air pressure. When air is not available in the reservoirs one trolley on each unit is arranged so that it may be unlocked and raised by a small hand pump.

On each unit there are four liquid rheostats, one for each motor. The rheostats are operated in pairs, and provide the motor circuit resistance required in order that the speed of the motors may be slow at starting and may be gradually increased as the resistance is cut out of circuit.

The principal dimensions and weight of each complete locomotive is as follows:

Length overall	105 feet	8 inches
Driving wheel base, total	83 feet	10 inches
Rigid wheel base	11 feet	0 inches
Truck wheel base	16 feet	6 inches
Height, rail to pantagraph (locked)	16 feet	0 inches
Height, rail to top of cab (maximum)	14 feet	9 inches
Width overall (maximum)	11 feet	6¼ inches
Diameter of driving wheels		62 inches
Diameter of pony wheels		30 inches
Weight on drivers	220 tons	
Total weight of locomotive	270 tons	

The following table shows the performance of these locomotives under varying conditions of load:

	Train on 1.5 and 2 per cent grades	Train on 1 per cent grades	Train on 1.4 per cent grades
Weight of train—tons	3,250	3,250	3,250
Locomotives per train	2	1	1
Approximate speed, miles per hour	14	14	28
Drawbar pull per locomotive, pounds			
Uniform acceleration	91,800	114,000	79,400
At speed on 2 per cent grade	75,400		
At speed on 1 per cent grade		85,800	
At speed on 0.4 per cent grade			4,600
Maximum guaranteed accelerating tractive effort per locomotive	133,000	133,000	90,000
Approximate maximum guaranteed horse-power developed by motors	5,000	5,000	6,700

On tests and in service the locomotives have developed a drawbar pull considerably in excess of the guaranteed maximum. The highest record with the dynamometer car being 180,000 pounds. This corresponds to an adhesion of about 40 per cent.

Problems of Geographic Influence*

Geography offers help and co-operation to all sciences that deal with man, anthropology, ethnology, history, sociology, economics, psychology and comparative religion, and from each of these geography will gather data for its own perfecting.

The historian, for example, needs from the geographer a more full knowledge of environmental working, and the geographer receives in turn much from the historian. The old geography knew little of the causal and historical, and some of the old history might just as well have been staged on a flat platform projected into the interplanetary ether.

If history is to strike deep roots into the earth, if it is to set forth with full discernment, the molding, moods, motives, and movements of men, the historian will need help from the geographer; and the historian, skeptical of generalizations that are too easy and scorning overstatement, will respond with open hand to every real offering of the geographer.

When geography was poorer than to-day, Parkman wrote the human story out of its environment. James Bryce has always and without stint placed geography in the running with historical movements. And if the generalizations of Bryce, like those of Ratzel, are sometimes tinged with vagueness, let us blame, not the historian of broad outlook, but the geographer whose work is yet in arrears. Other examples are not wanting. Winsor, in dedicating his Mississippi Basin to Mr. Markham, then president of the Royal Geographical Society, writes of environment:

"I would not say that there are not other compelling influences but no other control is so steady."[1]

Mr. Edward John Payne has written a "History of the New World called America." Being no historian, I do not know the craft's estimate of that work, but I am astounded at the author's deep and broad knowledge of environment in the lands whose story he tells. The surface, the climate, the possibilities of cereal production and of the domestication of certain animals appear in such wise in relation to early American civilization, to the arts and habits of the people, as to stir the geographer to admiration. Whether all of Payne's conclusions stand fire or not, he gives an example of effort aimed at precision. This is a call to every geographer. The geographic atmosphere in Prof. Turner's story of our north central west is known to us, and Prof. J. L. Myres, reaching at once broadly into the fields of classic lore, anthropology and geography, is, in his person and work, living testimony to the importance of our anthropogeographic task, and to the hopefulness that lies in our attempting it.

Some historical writers are influenced little, if at all, by the study of the earth and lower life as elements of human environment. Even volumes professing to deal with the geographic foundation of history sometimes fail of their goal, and one preface affirms that—"the general physiography of North America is familiar enough to readers."

This, I am sure, is quite too rosy a view of the geographic situation. But I cite the limitations of some histories in no mood of criticism. Let every man build the wall over against his own house. What of assured fact or proven principle we put before the historian he has neither the will nor the power to escape. Our light is in no danger of being put under a bushel. But we have good need to see that it is lighted.

If we turn to sociology we meet the insistence on the importance of environment. Let us take Giddings's definition, that "sociology is an attempt to account for the origin, growth, structure, and activities of society by the operation of physical, vital and psychical causes, working together in the processes of evolution."

Or we may cite the utterance of Small, that "this force is incessant, that it is powerful, that it is a factor which may never be ignored."[2] Yet Dr. Small in an extended chapter on environment mentions geography but once, and then not as a science which might contribute to sociology. Prof. Ridgeway[3] thinks that failure fully to recognize man as controlled by the laws of the animal kingdom leads to maladministration of alien races and blunders in social legislation. He says, further, "As physical characteristics are in the main the result of environment, social institutions and religious ideas are no less the product of environment," and again, any attempt to eradicate political and legal institutions of an equatorial race "will be but vain, for these institutions are as much part of the land as are its climate, its soil, its fauna, and its flora." Ripley, in reviewing the second volume of Ratzel's anthropogeography, criticizes the author for neglecting acclimation, considering its importance in social theory, and in view of the fact that theories of race dispersion turn upon our judgment in this matter. Perhaps the real state of the case is seen in the appearance not long ago of a serious and careful volume on the development of western civilization, which nevertheless exhibits an utter dearth of geographic data and also principles.

We are safe then in saying that most authorities in these sciences of man recognize environment as fundamental, but the greater part, in a sort of absolution of conscience, name the subject and take leave of it.

We need not, therefore, expect the historians or the sociologists to develop in any full way the principles of environmental action. They admit the need of these principles, but have not the time, perhaps not the will, to develop them. It remains for us to put content into the word environment, so that it cannot be overlooked or slighted, and so that its meaning may become available in plain terms to all.

In his "Racial Geography of Europe" Ripley asserts that: "To-day geography stands ready to serve as an introduction as well as a corrective to the scientific study of human society."

This was written about twenty years ago, and yet it is to-day not so valid or truthful a statement as we could desire it to be. Our convictions are in the right place and much has been done, but we still suffer from a dearth of limited, local, special and proven data, and a surplus of generalizations announced with the enthusiasm of fresh discovery, or rediscovery, unsupported by adequate evidence. We are subject to Marett's criticism of certain generalizations of Ratzel and La Play—"too pretty to be true."[4] We are awaking to the importance of our field, and this is well, but it is equally important to make haste slowly and to give human geography a content satisfying to ourselves and convincing to our fellow workers in adjoining fields.

The pursuit of our theme is as difficult as it is important. Prof. Cramb in a recent book[5] comments on the causal idea so common in our modern thought about history. His word is equally good for us. He says:

"In man's history nothing is more difficult than to attain to something like a just conception of a true cause."

Universality and necessity are the criteria which he proposes. A stiff application of these principles would be a tonic for some geographical theorizing.

* Abstracts from the address of Prof. Albert P. Brigham, president of the Association of American Geographers, at the eleventh annual meeting at Chicago.

1 "Mississippi Basin," Justin Winsor, following title page.

2 "General Sociology," A. W. Small, 417.

3 William Ridgeway, "The Applications of Zoological Laws to Man," *Brit. Assoc. Ad. Sci.*, Dublin, 1908, 832-847.

4 R. R. Marett, M.A., "Anthropology," 98.

5 J. A. Cramb, "Germany and England," 113.

One of the principal exhibits at the Panama-Pacific Exposition is one of the Pennsylvania Railroad electric locomotives mounted on a 65-foot turntable. This locomotive is said to be the largest in the world in passenger service. It consists of two units and weighs 156 tons, and is the first side-rod gearless locomotive ever placed in service. It has two motors having a total capacity of 4,000 horse-power.

The Time System of the United States

Why It Exists and Some of Its Vagaries and Defects

By Charles T. Higginbotham

Our present method of calculating and indicating time is a legacy from the ancient Romans. Having become accustomed to it through long years of use we fail to notice its shortcomings, inconsistencies, and absurdities. It is only when our attention is particularly directed to some glaring inconsistency or some unbearable hardship that we wake up to the situation and take measures to relieve ourselves of some burden that it imposes upon us.

Such a condition forced itself upon the attention of the public in 1883. Previous to that year each city and town reckoned its time from its meridian. This is to say, from the meridian passing through that particular place. It was impracticable for railways to arrange their time tables to conform strictly with this condition. Some attempts made to do so created considerable confusion. It necessitated the engineer and other train hands setting their watches at nearly every important station. This proved a very costly practice to the railroad companies and was the direct cause of some disasters. There were upward of fifty different kinds of railway time in the United States, and it was a usual thing for jewelry stores to provide their regulators with two minute hands, one for local time and one for railway time. This caused so much inconvenience to the public and became such a source of trouble to railway managers that, in order to relieve the situation, an agreement was entered into to adopt four meridians from which time for the United States should be taken.

The meridians adopted for this purpose were the 75th, from which Eastern time is taken. The 90th, for Central time, the 105th for mountain time, and the 120th for Pacific time. These meridians are 15 degrees apart, making a difference in time of exactly one hour between each. All the railways throughout the United States now arrange their time tables approximately in conformity with these meridians.

On November 18th, 1883, this new system went into effect and there was a general re-setting of clocks and watches all over the country. Every city and town now uses for its local time one of these meridians, the one used being identical with that used by the railways passing through, or terminating at that place.

To fully comprehend the use of these meridians it must be borne in mind that longitude is universally reckoned from Greenwich. Every sea captain all over the world, regardless of from what port he sails or to what port he is bound, sets his chronometer by Greenwich time. It must also be borne in mind that the time occupied by the earth in making a revolution is 24 hours. Dividing 360 degrees by 24 hours gives 15 degrees; consequently 15 degrees has a time value of one hour. This is to say, the apparent motion of the sun from east to west is at the rate of 15 degrees per hour.

The meridians, it will be understood, run north and south. The 60th, from which Atlantic time is taken, passes through the eastern parts of the province of Quebec and New Brunswick, Canada. This meridian is used on some of the Canadian railways, but is not used in the United States. The 75th meridian, from which Eastern time is reckoned, passes through Herkimer, New York, Western New Jersey and Eastern Pennsylvania, about midway between Trenton and Philadelphia. The 90th meridian, from which Central time is reckoned, passes through the extreme eastern edge of Minnesota, the western part of Michigan, the center of Wisconsin; through Illinois, 17 miles west of its capital—Springfield—and 12 miles east of St. Louis, through the extreme eastern parts of Missouri and Arkansas, the western part of Tennessee, 3 miles east of Memphis, through Mississippi, 2 miles west of Jackson, and through the eastern side of Louisiana, 5 miles east of New Orleans. The 105th meridian, from which mountain time is reckoned, passes through eastern Montana, 40 miles east of Miles City; through eastern Wyoming, 10 miles west of Cheyenne; through Denver, and 10 miles west of Colorado Springs; through New Mexico, 50 miles east of Santa Fé; and through the extreme west of Texas, 85 miles east of El Paso. The 120th meridian, from which Pacific time is reckoned, passes centrally through the States of Washington and Oregon, forms the dividing line between Nevada and California, to a point 12 miles west of Carson City, thence through the center of California.

The 90th meridian furnishes time for a larger area than any other. As a matter of fact it supplies time to 55 per cent of the population of the United States. It requires three meridians to supply the remaining 45 per cent. There are, however, confusing irregularities caused by the locations selected by the railway companies for changing their time schedules. This is unavoidable. Railways cannot be expected to change time exactly midway between meridians. They usually select the termination of divisions for that purpose. As a result the Eastern and Western boundaries of the area using Central time form zigzag lines. This condition is productive of strange situations. Traveling from Greensburg, Kansas to Beverly, Nebraska—a distance of about 200 miles due north—it becomes necessary for the traveler, if he would have his watch agree with the time used in the different towns through which he passes, to set it four times during his journey. This is owing to his crossing the zigzag boundary lines as laid out by the railroads.

Whenever a change of time is made by a railway there must of necessity be two kinds of time at that place. At Pittsburgh they are Eastern and Central. Trains going east use the former, and those going west the latter. Buffalo has the same condition in an exaggerated form, for the reason that all trains going east use eastern time, while trains going west use both eastern and central. The Grand Trunk, the Michigan Central and the Wabash use Eastern time, while all roads south of Lake Erie use Central. Trains arrive and depart from El Paso, Texas, on four different kinds of railway time: Central, Mountain, Pacific and Mexican. It is impossible to estimate the loss to the traveling public from mistakes caused by this confusing state of affairs, but in stating that the monetary loss to the public from time spent in efforts to decipher and unravel the complications in our railway time tables, brought about by our present confusion system is $5,000,000, would not seem to be very far from being correct. That this is not an exaggerated estimate may be seen when we consider that American railways carry two and a half million passengers daily. If the average loss of time in deciphering and studying time tables is one half cent per passenger the yearly aggregate would amount to $4,562,500. In addition to this our complicated system involves increased labor and expense to the railway companies in making out their time tables. Here then we have $5,000,000 a year absolutely wasted. Enough to build a battleship, and this does not take into account the amount lost by mistakes arising from the same cause.

Another fruitful source of confusion and mistakes is the method of dividing the day and night into two periods of 12 hours, numbered, 1 to 12, necessitating the use of those awkward and inconvenient affixes A. M. and P. M.

The Egyptians were the first to divide the day and night into 24 equal parts. They numbered the hours 1 to 24. The Romans began their day at sunrise, numbering the hours to sunset 1 to 12, and numbering them from sunset to sunrise also 1 to 12. Our A. M. and P. M. is a part of the burdensome legacy inherited from them. The hours constituting their day and night were of unequal and constantly varying lengths. In course of time they made a change to our present system, and had they adopted the Egyptian method they would have conferred an inestimable benefit upon mankind.

The remedy for the evils we have described lies: First, in numbering the hours as the Egyptians did. Beginning, as we now do at midnight we would number the hours up to noon 1 to 12; the hour we now designate as 1 P. M. would be 13, and so on to 24. Second, we should adopt one meridian for the entire United States, which could be done without any serious disturbance of affairs. The change which was made in 1883 was hardly noticed and proved a great benefit without working hardship on anyone. The advantage secured by that change was insignificant as compared to the advantage to be secured by the use of one meridian and the 24-hour system.

Canada has already adopted the 24-hour system on all her railroads west of Port Arthur, and China has adopted one meridian for the entire empire, which embraces 60 degrees, the same amount as the United States. Shall we allow ourselves to be left behind by other nations?

Let us suppose that the 90th degree—central meridian—should be adopted as the one from which United States time should be reckoned; what then would be the effect on business? The hour of 8 A. M. is now pretty generally adopted for the commencement of business. If we should take our time from the central meridian it would be 9 in New York, 8 in Chicago, 7 in Denver and 6 in San Francisco; but what matters it where the hands of the clock point so long as business commences the same amount of time after sunrise? Clocks and watches should be our servants, not we theirs.

On April 15th the sun rises at Philadelphia at 5 o'clock as we now reckon time. This is to say, the Philadelphians commence business 3 hours after sunrise. The only difference that the change would produce is that the hands of their clock would point at 9 instead of 8.

We would soon become accustomed to the proposed change and the great benefit and saving resulting therefrom would repay us many times over for any slight inconvenience that might at first be felt. With this system in force there would be no setting and resetting of traveler's or railroad employee's watches. One might travel from coast to coast without disturbing his watch. The reading of railway time tables would be so simplified that there would be no excuse for making mistakes. The absurdities that now exist in the matter of time would be eliminated.

By our present system of reckoning time it would have been possible for an event to have occurred in New York on January 1st, 1911, at 1 A. M., and for that event to have been known in San Francisco at 10 P. M., December 31st, 1910. It is now possible to leave El Paso for the West one hour and fifty minutes before you arrive from the East—according to railway time tables. The writer recently saw the apparent anomaly of two trains standing side by side in the station at Buffalo, both headed for the West, yet the engineers' and conductors' watches on one train were just one hour ahead of the other. This sort of incongruity would be impossible with the proposed new system.

Half a century ago there was not a watch in existence capable of meeting the requirements of American railway time service to-day. Railway time inspection has set the limit of variation from true time, for its employees' watches, at 30 seconds a week. This means that the balance wheel shall not vary in its motion to the extent of one vibration out of every 20,000. Taking into consideration the various causes of disturbance to which a railway engineer's watch is subjected, the jolts and jars, the changes of temperature and the magnetic influence incidental to the proximity of large masses of iron and steel, this performance is truly remarkable. That it is possible to secure such accuracy in such a tiny piece of mechanism subjected to those adverse influences is little short of marvelous, and justifies the claim that the watch of to-day is the most wonderful piece of mechanism that the ingenuity of man has ever produced.

The requirement for accuracy in railway watches in particular, and for others as well, is becoming more exacting every day. Horologists are at their wits' end to meet them. The time is surely coming when a purely mechanical device will no longer suffice to produce sufficient accuracy. What then? Some other force of nature must be enlisted. What will it be? What else but that mysterious force, electricity? That wonderful power which is being harnessed to lighten man's burdens and minister to his wants and pleasures. Yes: Wireless Electricity is destined to solve the problem.

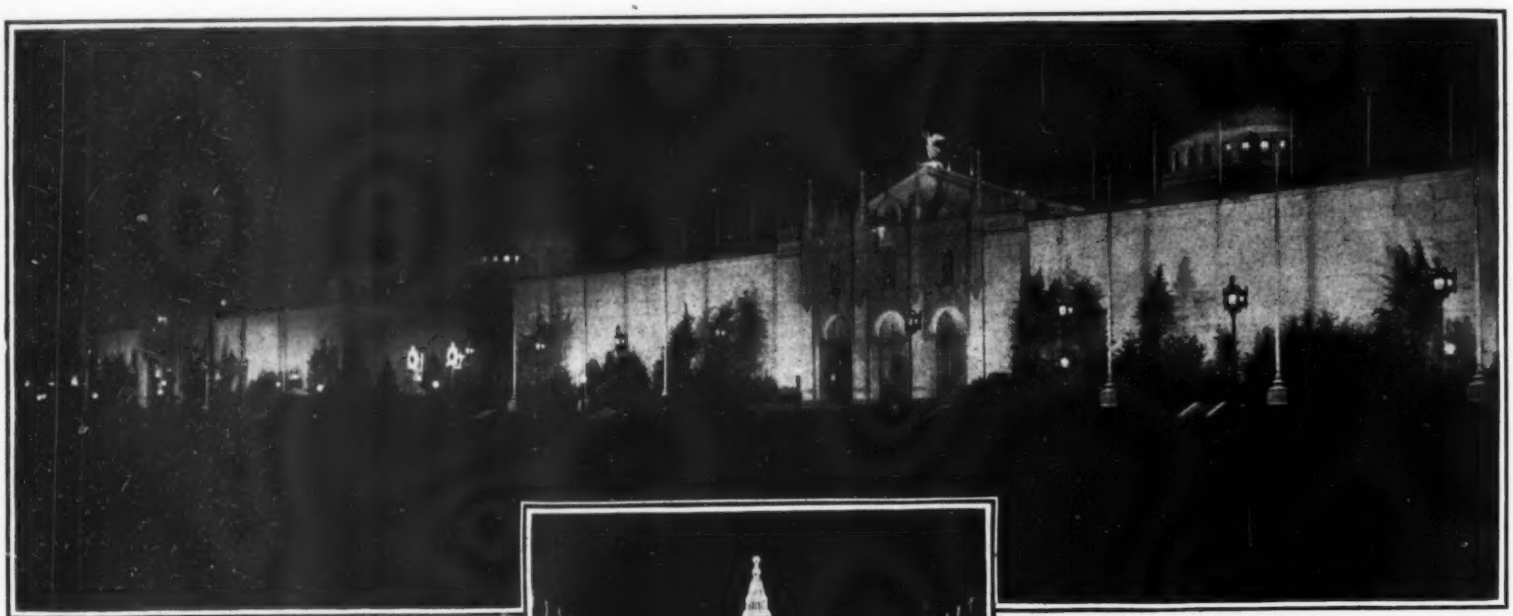
The time is now sent out from the observatory at Washington from an astronomical clock, so protected against all disturbing influences that it runs with infinitesimal variation, and is corrected by nightly stellar observations. Centrally located clocks controlled from this master clock at Washington will be used to send out aerial electric waves. These clocks will control a radius of, perhaps, one hundred miles. The watch and the clock of the future, like their precursors, the sun-dial and the clepsydra, will be relegated to the shelves of our museums, their places taken by electric receivers contrived to indicate time received from these central clocks. The railway engineer will no longer depend upon a mechanical contrivance which is always liable to error in its indications of time. He will press a button and read the time to the second, in exact conformity with the accurate astronomical clock at Washington. The little instrument which he carries will be no larger than a watch.

It may be asked: Will not the new instrument be liable to get out of order, and give incorrect time? No! The new instrument will never lie. It may get out of order, but will never lead to a mistake. It will either indicate correct time or no time at all.

Illumination of the Panama-Pacific Exposition*

Wonderful Effects Produced by Modern Apparatus and the Engineer's Art

By W. D'A. Ryan, Chief of Illumination



Palaces of Transportation and Mines softly illuminated by reflected light.

The Tower of Jewels.

The illumination of the Panama-Pacific International Exposition is a development in the art of illumination made possible by the science of lighting which grew up under the name of illuminating engineering and had its inception at the Thomson-Houston plant of the General Electric Company at Lynn, Mass., nearly 20 years ago.

While in charge of the expert course, the writer came closely in contact with the development of the Thomson '93 arc lamps which in various ornamental forms were designed for alternating and direct current series and multiple circuits. The inclosed arcs soon made their appearance and these lamps added to the existing lighting sources suggested the necessity of a careful scientific study in the selection, location, reflectoring and globing of the various units to obtain maximum results at minimum cost for industrial use, store and street lighting, and other purposes.

That illuminating engineering was to form such an important specialized branch of electrical engineering was not at first recognized, but after considerable progress had been made in this particular field the title of Illuminating Engineer became generally acknowledged. From that time on the development has been very rapid. New photometers, luximeters, and luminometers were built for laboratory and field work. Lumichromoscopes were designed for studying effects of different lights on various colored materials, diffusers made their appearance, scientific glassware and reflectors swept over the land, extensive laboratory and field tests were made and the development became general.

In lighting propositions involving special effects or treatment, it has become the practice to employ an illuminating engineer in addition to the electrical engineer. It was therefore natural that when the Panama-Pacific International Exposition decided that its illumination should possess features of novelty to correspond with its general policy it recognized the necessity of establishing a department of illuminating engineering in addition to the electrical and mechanical department, which came under the direction of Mr. G. L. Bayley.

Mr. Bayley's application to the General Electric Company resulted in the writer's appearing before Mr. H. D. H. Connick, director of works, and the architectural commission in August, 1912, to consider the preparation of lighting plans along original lines. Three months later a scheme and scope was presented to the architectural commission and the writer was officially appointed "Chief of Illumination" in charge of the illuminating and spectacular effects, also the design of lighting standards and fixtures and the selection of the glass for the buildings and various lighting units.

As a result, for the first time in history the lighting of an International Exposition was completely designed and charted before the buildings were erected.

A detailed description of the lighting in a limited space is, of course, impossible, and it is the purpose of this article to convey a general idea of the effects rather than the means employed to produce them.

* The General Electric Review.

The illumination of the Exposition marks an epoch in the science of lighting and the art of illumination. Like many other features of the Exposition, the illumination is highly educational in character and emphasizes more than anything that has gone before the result of concentrated study in the best uses and application of artificial light.

Previous exposition buildings have, in the main, been used as background on which to display lamps. The art of outlining, notably the effects obtained at the Pan-American Exposition at Buffalo, could probably not be surpassed. This method of illumination has, however, been extended to amusement parks throughout the world and is now commonplace. Its particular disadvantage is that it suppresses the architecture which becomes secondary and it is practically impossible to obtain a variety of effects, so that the Exposition from every point of view presents more or less similarity. Furthermore, the glare from so many exposed sources, particularly when assembled on light colored buildings, causes eye strain. Prior to the opening night of the Exposition, there were many who maintained that the public would not be attracted except by the glare of exposed sources and great brilliancy, which was analogous to saying that the masses could be attracted only by one form of lighting. The results obtained, however, clearly disproved this theory.

The lighting effects are radical, daring and in every sense new, the fundamental features of which consist primarily of masked lighting diffused upon softly illuminated facades emphasized by strongly illuminated towers and minarets in beautiful color tones.

The direct source is completely screened in the main vistas and the "behind the scenes" effects are minimized to a few locations and are nowhere offensive.

Furnishing wonderful contrast to the soft illumination of the palaces, with their high lights and shadows, we have the Zone, or amusement section with all the glare of the bizarre, giving the visitor an opportunity to contrast the light of the present with the illumination of the future. As we pass from the Zone with its blaze of lights, we enter a pleasing field of enticement or carnival spirit. We are first impressed with the beautiful colors of the heraldic shields on which is written the early history of the Pacific Ocean and California. Behind these banners are luminous arc lamps in clusters of two, three, five, seven and nine, ranging in height from 25 to 55 feet. We look from the semi-shadow upon beautiful vistas, and the Guerin colors which fascinate in the daytime are even more entrancing by night. The lawns and shrubbery surrounding the buildings and the trees with their wonderful shadows appear in magnificent relief against the soft background of the palaces and the "Tower of Jewels" with its 102,000 "Nova-gems," or so-called exposition jewels, standing mysteriously against the starry blue-black canopy of the night, surpassing the dreams of Aladdin.

As we enter the "Court of Abundance" from the east, with its masked shell standards strongly illuminating the cornice lines and gradually fading to twilight in the foreground, we are impressed with the feeling of mystery analogous to the prime conception of the architect's wonderful creation. Soft radiant energy is everywhere; lights and shadows abound, fire spits from the mouths of serpents into the flaming gas cauldrons and sends its flickering rays over the composite Spanish-Gothic-Oriental grandeur. Mysterious vapors rise from steam electric cauldrons and also from the beautiful central fountain group symbolizing the Earth in formation. The cloister lanterns and the snow-crystal standards give a warm amber glow to the whole court and the organ tower is carried in the same tone by colored searchlight rays.

Passing through the "Venetian Court," we enter the "Court of the Universe," where the illumination reaches a climax in dignity, thoroughly in keeping with the grandeur of the court, where an area of nearly half a million square feet is illuminated by two fountains, rising 95 feet above the level of the sunken gardens, one symbolizing the rising sun and the other the setting sun.

The shaft and ball surmounting each fountain is glazed in heavy opal glass which is coated on the outside in imitation of travertine stone so that by day they do not in any sense suggest the idea of being light sources. Mazda lamps installed in these two columns give a combined initial mean spherical candle-power of approximately 500,000 and yet the intrinsic brilliancy is so low that the fountains are free from disagreeable glare and the great colonnades are bathed in a soft radiance. For relief lighting three Mazda lamps are placed in specially designed cup reflectors located in the central flute to the rear of each column. This brings out the Pompeian red walls and the cerulean blue ceilings with their golden stars and at the same time the sources are so thoroughly concealed that their location cannot be detected from any point in the court.

The perimeter of the "Sunken Garden" is marked by balustrade standards of unique design consisting of Atlantes supporting urns in which are placed Mazda lamps of relatively low candle-power. The function of these lights is purely decorative.

Illuminated outer vestibule of Fine Arts Building.

Festival Building illuminated by diffused light.

The great arches are carried by concealed lamps, red on one side and pale yellow on the other, thereby preserving the curvature and the relief of the surface decorations. The balustrade of this court, 70 feet above the sunken garden, is surmounted by 90 seraphic figures with jeweled heads. These are cross lighted by 180 Mazda searchlights, the demarcation of the beams being blended out by the light from the fountains of the rising and the setting sun.

Passing through the Venetian Court to the west, we enter the "Court of the Four Seasons," classically grand. We are now in a field of illumination in perfect harmony with the surroundings, suggesting peace and quiet. The high current luminous arcs mounted in pairs on 25-foot standards masked by Greek banners are wonderfully pleasing in this setting. The white light on the columns causes them to stand out in semi-silhouette against the warmly illuminated niches with their cascades of falling water, and the placid central pool reflects in marvelous beauty scenes of enchantment.

Having reviewed in order illuminations mysterious, grand and peaceful, we emerge from the West Court upon lighting classical and sublime, the magnificent Palace of Fine Arts bathed in triple moonlight and casting reflections in the lagoon impossible to describe. The effect is produced by searchlights on the roofs of the Palaces of Food Products and Education supplemented by concealed lighting in the rear cornice soffits of the colonnade.

You have only passed through the central, east and west axis of the Exposition. There are many more marvels to be seen. If you wish to study the art of illumination you could visit the Exposition every evening throughout the year and still find detail studies of interest. For instance, did you ever see artificial illumination in competition with daylight? On certain occasions the projectors flood-light the towers before the sun goes down. If you are fortunate enough to be present, take up a position in the northwest section of the "Court of the Universe" and watch the marvelous effect of the "Tower of Jewels" as the daylight vanishes and the artificial illumination rises above the deepening shadows of the night. The prismatic colors of the jewels intensify and the tower itself becomes a vision of beauty never to be forgotten.

The South Garden may very properly be called the fairy-land of the Exposition at night. When the lights are first turned on, the five great towers are bathed in ruby tones and they appear with the iridescence of red hot metal. This gradually fades to delicate rose as the flood-light from the arc projectors converts the exterior of the towers into soft Italian marble. The combination of the projected arc light (white) and the concealed Mazda light (ruby) produces shadows of a wonderful quality. Each flag along the parapet walls has its individual projector which converts it into a veritable sheet of flame.

As a primary line of color the heraldic shields and cartouche lamp standards produce a wonderful effect against the travertine walls bathed in soft radiance from the luminous arcs which also bring out the color of the flowers and lawns and create pleasing shadows in the palms and other tropical foliage. This is supported by a secondary effect in the decorative Mazda standards along the "Avenue of Palms" and throughout the garden. A finishing touch is added by the effect of life within created by the warm orange light emanating from all the Exposition windows supported by red light in the towers, minarets and pylon lanterns.

To the west we have the enormous glass dome of the Palace of Horticulture converted into an astronomical sphere with its revolving spots, rings and comets appearing and disappearing above and below the horizon and changing colors as they swing through their orbits. The action is not mechanical, but astronomical.

To the east, we have the "Festival Hall" flood-lighted by luminous arcs and accentuated by orange and rose lights from the corner pavilions, windows, and lantern surmounting the dome, all reflected in the adjacent lagoon and possessing a distinctive charm which will long remain in the memory.

Purely spectacular effects have been confined to the scintillator at the entrance of the yacht harbor. This consists of 48 36-inch projectors having a combined projected candle-power of over 2,600,000,000. This battery is manned by a detachment of United States Marines.

A modern express locomotive with 81-inch drivers is used to furnish steam for the various fireless fireworks effects known as "Fairy Feathers," Sun-burst," "Chromatic Wheels," "Plumes of Paradise," "Devil's Fan," etc. The locomotive is arranged so that the wheels can be driven at a speed of 50 or 60 miles per hour under brake, thereby producing great volumes of steam and smoke, which, when illuminated with various colors, produces a wonderful spectacle.

The aurora borealis created by the searchlights reaches from the Golden Gate to Sausalito and extends for miles in every direction. The production of "Scotch Plaids" in the sky and the "Birth of Color," the weird "Ghost Dance," "Fighting Serpents," the "Spook's Parade" and many other effects are fascinating.

Additional features consist of ground mines, salvos of shells producing "Flags of All Nations," grotesque figures and artificial clouds for the purpose of creating midnight sunsets.

Over 300 scintillating effects have been worked out and this feature of the illumination is subject to wide variation. Atmospheric conditions have a great influence upon the general lighting effects; for instance, on still nights the reflections in the lagoons reach a climax particularly the Palace of Fine Arts as viewed from Administration Avenue; the facades of the Education and Food Products Palaces as seen in the waters through the colonnade of the Palace of Fine Arts; the Palaces of Horticulture and Festival Hall from their respective lagoons in the South Garden; the colonnades and the Nova-gems on the heads of the seraphic figures, and the "Tower of Jewels" as reflected in the water mirror located in the North Arm of the "Court of the Universe."

On windy nights the flags and jewels are at their best. On foggy nights wonderful beam effects are produced over the Exposition impossible at other times. When the wind is blowing over the land the scintillator display is different from nights when the wind is blowing across the Bay. A further variety is introduced in the action of the smoke and steam on calm nights.

On the evening of St. Patrick's Day all the searchlights were screened with green; not only the towers but every flag in the Exposition took on a new aspect.

Orange in various shades was the prevailing color for the evening of Orange Day and on the ninth anniversary of the burning of San Francisco the Exposition was bathed in red, with a strikingly realistic demonstration of the burning of the "Tower of Jewels."

High pressure gas lighting plays an important part in street lighting in the foreign and State sections; low pressure gas for emergency purposes, and gas flambeaux for special effects.

The accompanying illustrations suggest some idea of the illumination, but the addition of color is absolutely necessary to convey anything approaching a correct impression of the night pictures of the Exposition.

Strength of Wireless Signals

In a recent lecture delivered by Prof. Marchant at the Liverpool University before the Institution of Electrical Engineers he described an apparatus that he had used to measure the strength of signals received from distant places, and he showed by diagrams how the strength was influenced by atmospheric conditions. Between two stations lying nearly northwest and southeast of each other the strength of signals during the daytime varied within comparatively narrow limits. The ratio between the night and the day strengths varies with the time of year and also from day to day of any given month. On the evening of a fine, clear day the improved strength known as the "sunset effect" really occurs about three quarters of an hour after sunset, and it varies with the weather conditions. When rainy conditions prevail the strengthening of the signal after sunset is much less marked. The variations during the night are relatively great, and occur within the space of a few minutes.

Electrometallurgy—I*

Modern Methods for Producing and Refining Various Metals

By Joseph W. Richards

I WISH to clear the ground first with a few advance remarks as to what electrometallurgy is. One definition of metallurgy is, "The art of making money out of ores." The technical definition is, "The art of extracting metals out of ores and refining them to the purity required by everyday use." Metallurgical operations are mostly chemical operations. Ores, with a few exceptions, contain the metals as compounds, and not in their native state. Therefore, it is usually a matter of decomposing the compound, as easily and cheaply as it can be done, by means of chemical reagents. Electrometallurgy is the art of utilizing the electric current in obtaining metals from their ores, or in refining them for industrial purposes.

The main divisions of electrometallurgy are, first, the electrolytic methods, and, second, the electro-thermal:

I. Electrolytic Methods.—1. Aqueous solutions: (A) Soluble anodes—electroplating, Au, Ag, Ni, brass; electro-refining, Cu, Pb, Ag, Au, Bi, Sb, Zn. (B) Insoluble anodes—extraction from solution, Cu, Zn, Au, Ag; cathodic reduction, Pb. 2. Fused salts (electrolytic furnaces): (A) Simple salts, Na, Ca, Mg, Ce, Zn; (B) solutions in fused baths, Al.

II.—Electro-thermal Methods (Electric Furnaces).—1. Fusion of metals or alloys—steel, brass, bronze, aluminum. 2. Reduction of compounds to metals or alloys—B, Si, Mn, Zn, ferro-alloys, pig iron, pig steel.

Electric current can be utilized for electrolytically decomposing chemical compounds. The electro-thermal method is that in which the current is used for its heating power only, and in which some other agent does the decomposing. These two are very distinct from each other, and I will spend a few minutes in emphasizing the difference between them.

In the electrolytic method you depend upon the electrolytic decomposing power of the current. You necessarily have to use a direct current except where the electric cell itself rectifies the current, which is very exceptional. In all practical electrolytic operations, only direct current is used. In electro-thermal work, where the current is used for its heating power only, direct current or alternating current may be used. Alternating current is cheaper and does not give the indirect effects that a direct current will give, for with direct current in an electric furnace you usually have undesired one-sided effects at the electrodes.

In the electrolytic furnace, the amount of useful work done, as measured by the amount of the product, is proportional to the amperes of the current which pass, according to the laws discovered by Faraday. When you are passing a current through an electrolytic cell, the amount of product is independent of the volts which may be expended on the cell, and is dependent only upon the amperes. It is only secondarily that the volts used affect the amount of product which can be obtained by forcing through more amperes. It is easy to calculate the theoretical amount which you should get at 100 per cent ampere efficiency upon the amperes flowing through any electrolytic cell.

In electro-thermal work, the heat-energy of the current is that which is utilized, and the heat effect is proportional to the amperes multiplied by the volts, so that the product will be proportional to and determined by the amount of energy which is expended upon the furnace as measured by the Killowatt hour meter. The two processes are thus seen to be essentially distinct in these two fundamental ways. A third distinction may also be drawn between them—that in the electrolytic apparatus you must have an anode and a cathode arranged for proper electrolysis, and proper arrangements for the escape of the gaseous products at the cathode. In the electro-thermal methods you have no such distinction of parts. There may be electrodes, or the terminals or poles; but they are not positive and negative, they are not anode and cathode, and there is no arrangement of the cell which copies or duplicates the electrolytic arrangement which is necessarily part of an electrolytic operation.

I will discuss now why the electrolysis of fused salts is sometimes classed erroneously under the electric furnace methods. Fused salts generally conduct current freely. Their order of resistivity is that of a well-conducting aqueous solution like the best conducting sulphuric acid, something like one to three ohms per centimeter cube. When you pass the current through and decompose fused salts, the operation is primarily electrolytic—the decomposition of affused salt to obtain its ingredients. However, you cannot pass an electric current through any solution, or, in fact, through any material, without generating some heat by the passage of the current. If you electrolyze with an intense current you generate much heat, and you may reach a point where the internal heat generated by the passage of the current is so large as to keep the electrolyte melted without the assistance of the external heat with which you started the operation. By running the operation with an intense current, it is possible to get the salt melted, and keep it so, without the aid of electrolysis, thus incidentally generating enough heat to keep the salt liquid at the temperature at which you run—300 deg., 400 deg., or 1,000 deg. Cent.—such as when producing aluminum, etc.; and by regulating the current you can keep the temperature just at the desired point. Many writers have been muddled on this point, and have thought that when outside heat is dispensed with, you then have a furnace, and they have classed these with electric-furnace processes. That is taking them away from where they properly belong. The fact that the operation is essentially electrolytic is not affected by the fact that the heat generated partly suffices to keep the bath melted, and whether the heat generated keeps the bath melted, or whether you have even to cool it down, that does not affect the classification: it is not an electric-furnace process. I would ask you, when you read about electrometallurgical processes, that you will bear that in mind—that the electrolysis of fused salt, when the current supply is sufficient to keep it fused, is necessarily an electrolytic operation. Some people think that when you are conducting an operation requiring a higher temperature than the ordinary one, you necessarily have an electric furnace. This difficulty has been solved by using the term "electrolytic furnace" for an operation of this kind, where the electric current performs electrolysis and also supplies all the heat necessary to keep the salt melted.

Taking up now the different methods of electrometallurgy, starting with the use of aqueous solutions among the electrolytic methods, when the only source of electric current was the battery, the plating of silver, brass, etc., and other metals by means of an aqueous solution and electric current was the only branch developed. Elkington brothers, in England, were the best known platers of gold, silver, and other metals, using aqueous solutions to do electroplating. According to my definition, electroplating with pure metal used as an anode would not be included in electrometallurgy, and I should say at the present time that electroplating with a pure metallic anode is not an electrometallurgical operation in the strict sense. I mention this because in the early days, when the battery only was used as a source of current, electroplating was called electrometallurgy. In Mr. Shaw's first book, he assumes that electrometallurgy means nothing more than the plating of the metals, the duplicating of medals and coins, starting with a pure metal as anode, and simply changing its form and plating it over. From the old books up to the present you will find much in them about electroplating, or, in general galvanoplastics, the art of changing the form of a metal. Elkington Brothers, who were plating gold and silver, were the first to utilize this principle for refining copper, away back about 1865. When the first dynamo was invented—the first machine of Wilde—there arose the possibility of using impure copper as an anode, and plating out pure copper, thus saving all the gold and silver contained in the impure copper. That was the first process by which it was possible to extract gold and silver from the metallic copper when they were present in very small amounts, and the process owed its commercial success to treating cheap impure copper, saving the gold and silver, and at the same time obtaining a very pure copper at the cathode. That is a real electrometallurgical operation. It has a few fundamental principles, which I will set forth as concisely as I can.

To electrolytically refine impure metal, you must choose as electrolyte a soluble salt in solution—such that the actual metal you desire to get will go into the solution—and then you must use a depositing current of such quality and quantity that you deposit only the desired metal out of solution. When you take impure copper as anode, and thus electrolyze it, there remain undissolved, at the anode, the gold, the silver, the platinum, little specks of slag and matte, and particles of copper, which drop to the bottom. This anode mud will frequently be 50 per cent copper and 30 or 40 per cent silver and gold. The iron, nickel, zinc, cobalt, tin, and a number of other metals have gone into the solution. The current-density at the cathode must be high enough to deposit the copper, but low enough to let the impurities accumulate in the solution, whence they have to be removed by other means. Those principles are the foundation of the entire copper-refining industry, by means of which about 900,000,000 pounds of copper per year are refined for use in this country, the value running over one hundred millions of dollars. Similar principles are used for refining lead. For instance, Dr. Keith, of Philadelphia, worked out a very satisfactory laboratory process for refining lead many years ago. It was not satisfactory commercially, however; but in later years the problem has been solved by Mr. Anson G. Betts, and there are two or three such plants in operation in this country and abroad giving us a lead of very high purity, free from silver and gold, and particularly free from bismuth, which is one of the most difficult elements to get out of lead by ordinary refining processes. Bismuth remains behind in the slimes in such shape that it can be purified, and this process has increased very greatly the output of bismuth in this country. The lead is so free from bismuth that it commands a high price, being particularly desirable in the manufacture of white lead, for a trace of bismuth in white lead spoils its color.

Another element which is being electrolytically refined is zinc, which is more difficult to refine than copper or lead. There is also less margin commercially than there is for refining copper, and there is no gold or silver in it, whose saving pays for part of the operation, so the refining of it is not as profitable as that of copper.

The electrolytic refining of silver was first made practicable by Moebius. Taking as anode the silver bullion which comes from the cupellation furnace, the silver, copper, and iron go into solution, while the gold and platinum remaining are not dissolved. By properly regulating the depositing current, only pure silver is deposited. Silver of the greatest commercial purity is made in this way. Gold is electrolytically refined on the same general principles, but with differences in detail, by the Wohlwill process. The process was worked out at the Deutsche Gild und Silber Scheide Anstalt in Hamburg. A solution of chloride of gold, electrolyzed with a sheet of gold as anode, gives off chlorine into the air, and the anode is not dissolved. If you add hydrochloric acid to that solution, making a strongly acid solution, there comes a point where the escape of chlorine gets less and less, until its escape is prevented altogether, and the gold anode dissolves perfectly. That process was first put into operation in America, at our Philadelphia Mint. I believe the electrolytic plant has since been moved to the assay office in New York. The gold, platinum, and copper go into solution, while the silver forms chloride and remains undissolved. By using a proper depositing current, pure gold is obtained. The goldbeaters say they are getting much better results now from this commercial gold, because it is better than they were able to procure before by the acid chemical processes. The platinum is recovered from solution by a simple chemical operation, so that the platinum that used to stay with the gold and be lost is now saved.

Besides tin, lead, silver, copper, and gold, I believe there are other metals to which the electrolytic refining process is quite applicable. This is a large field, in which electrometallurgists are already working. Antimony and tin, for instance, have been worked on in this way. The general principles explained are applied, with differences in detail, to each one of the metals, enabling one to obtain the purest metals that have ever been put on the market. If you electrolyze a solution with an insoluble anode, you can extract the metal from the solution without replacing it by metal from the anode. There are a number of promising electrometallurgical processes included in this class of electrolytic processes.

1. When you dissolve the gold from gold ore in potassium-cyanide solution, the next problem is to get it out of solution. The way this is usually done is by chemical deposition by means of zinc. The electro-

* A paper read before the Engineers' Club of Philadelphia, U. S. A.

metallurgical method of extracting gold out of solution was used by Siemens and Halske in South Africa; but that method has had a hard struggle to compete with ordinary precipitation by zinc. Silver goes with the gold when it is deposited from a cyanide solution. If you look at the water in a copper mine, you will find it is frequently colored blue by sulphate of copper. That solution is usually run over scrap iron or pig iron to deposit the copper by a chemical reaction; but if you are handling solutions where iron is not available, it is possible to electrolyze it with an insoluble anode and throw down the copper, quite pure, on the cathode.

This year we have had news in the technical press of a very great development in this method of working in Chile. The Guggenheim's Chile Exploration Company has uncovered a large deposit of copper ore near Antofogasta which is soluble in dilute sulphuric acid. The ore is treated by dilute sulphuric acid, and, by electrolyzing the solution by insoluble anodes, the sulphuric acid for further treatment is regained. The main crux of that question was to find an insoluble anode which would not be attacked. Lead was used; but it forms lead peroxide, and gradually falls to pieces. A high-silicon iron was used; but that gradually falls to pieces. In Germany they are now casting magnetic oxide of iron (Fe_3O_4) into the shape of anodes, and using them successfully. They are about the shape of flattened baseball bats, hollow inside, with the walls a little over one-fourth of an inch thick. They are made in Frankfort-on-Main by the Griesheim Elektron Company. The Chile Exploration Company gave the Frankfort firm one order for $90,000 of these electrodes. It is interesting to consider that when they are immersed in the solution, the magnetite itself not being a good conductor, you would have considerable resistance in passing current down to the lower end. This is obviated by electro-depositing a shell of copper on the inside surface, fastening copper strips at the top to conduct the current into the inside shell, and then the only resistance which the current meets is about one-fourth of an inch of the magnetite to get from the inside to the outside. This work was described by Mr. E. A. Capellin Smith in New York before the American Electrochemical Society at its twenty-fifth general meeting in April last. That was the first public description of the operations in detail. That plant is designed to treat 6,000 tons of ore a day. An immense body of ore is available for treatment by this method.

You can get an idea of the importance of these methods of electrolysis with insoluble anodes from the few instances given. These magnetite anodes may also be quite useful in other electrolytic processes. In the generation of oxygen, for instance, they may find it practicable, for there has been trouble with anodes becoming corroded. I saw last Summer, in Butte, an operation of the same kind, of the Butte and Duluth Company, plating copper out from sulphate solution, and regaining the sulphuric acid for use again. The Phelps Dodge Company, which runs large copper mines in Arizona, has begun to study this method for its lowest grade of ores, and the main solution of this question rests on the use of insoluble anodes of fused magnetite.

(To be concluded.)

Cobalt Steel*

A New Material for Accelerating Machine Tool Speeds and Output

At the present time, when the need for increasing the output of our factories is so urgent, it is natural that engineers should be prepared to give attention to any practical suggestions that may lead to increased output.

One of these is that the merits of a comparatively new commercial product, cobalt steel, should be given a trial. Recent experiments have shown that tool steel made of a suitable alloy of iron, carbon, and cobalt is capable of speeding up to a remarkable degree any work in connection with the production of war material so far as turning, planing, slotting, drilling, and milling of iron and steel is concerned.

This special steel has been tested in America against a vanadium steel, the test being with ½-inch diameter twist-drill. The cobalt steel drill made 15,200 holes before the drill required to be ground, the hole depth being ½ inch through a malleable casting, and the drill running at 820 revolutions per minute under a large stream of oil. No other alloy steel drill could do better than 2,200 holes under similar conditions before regrinding. Such results are what would be expected after a scientific examination of the properties of alloy steels.

As Profs. J. O. Arnold, F.R.S., and A. A. Read, D.Met., state in the course of their well-timed paper on "The Chemical and Mechanical Relations of Iron, Cobalt, and Carbon," read at the last meeting of the Institution of Mechanical Engineers, scientific opinion as expressed by Sir Robert Hadfield, a cobalt-steel pioneer, is that the action of cobalt resembles that of nickel in raising the elastic limit and maximum stress of the material. The famous French metallurgist, M. Guillet, also found that "the presence of cobalt slowly raises the tensile strength and the elastic limit, while the elongation and reduction of area are diminished." The professor's own experiments proved that, with equal carbons, the tenacity of the steels, as measured by the yield-points and maximum stresses, increases with the cobalt, while the ductility, as measured by the elongation per cent, correspondingly falls.

Cobalt, they find, does not form a definite solid solution, or cobaltide of iron like that formed by nickel, which, with only 0.1 per cent of carbon present, registers a maximum stress of about ninety tons per square inch associated with a reduction of area of 45 per cent. An alloy containing about 13 per cent of nickel and 0.6 per cent of carbon is so hard that it is impossible to machine it, whereas in a series of cobalt steels in which the carbon ranged from 0.62 to 0.93 per cent and the cobalt from 2.7 to 20.9 per cent, all the alloys, without any annealing, machined with the greatest ease.

The heat treatment of cobalt steel is simpler than that of any other high-speed tool steel. Thus the forging of tools is done at a yellow heat, and hardening is effected merely by heating up the tool to a white heat and allowing it to cool in the open air. Super-heating to a fusing point is entirely unnecessary with cobalt steel and quenching in the usual media, such as air-blast, tallow, whale or linseed oil, molten lead, petroleum, or water, is not required. By obviating heating the tool up to the fusing point it is clear that grinding costs will be considerably reduced.

The Germans have recognized the merits of cobalt steel, and in a report just published by the Manchester Association of Engineers on "Past Experimental Work on Cutting Tools" we find Prof. G. Schleisinger of Charlottenburg arriving at the conclusion that "the employment of cobalt in the production of high-speed steels is followed by a remarkable increase in the cutting power and durability, without increasing the purchasing price above the average market price," which is about 3s 9d per pound.

How cobalt steel may be produced, according to Profs. Arnold and Read, is by melting together in suitable proportions ingots of pure cobalt, Swedish bar iron, and Swedish white iron, afterward adding pure metallic manganese and aluminium ten minutes before teeming. In their recent experiments, to which reference has already been made, the steels were cast into square molds, the ingots afterward being re-heated and hammered down into 1-inch round bars.

The advent of cobalt as a most valuable engineering material affords another example, along with tungsten and molybdenum, of the way in which what may be termed "chemical curiosity" metals have come to be of great industrial importance.

Until a few years ago cobalt had little use beyond forming the base of the pigment known as cobalt blue. In fact, as recently as 1912 a standard scientific work of reference could only record that "metallic cobalt is not at present used to any extent in the arts, though its utility is becoming more fully recognized."

The metal, which is similar in properties to iron, has a brilliant silver-white appearance when polished, and like iron is very magnetic, being, in fact, next to iron on the list of magnetic metals. It melts at 1,490 deg. Cent., as compared with 1,520 degrees for iron, while its specific gravity of 8.8 is well above that of iron, which is 7.8.

Canada is the world's principal producer of cobalt, practically all the cobalt of commerce emanating from the neighborhood of the town of Cobalt, which is situated in North Ontario, near the shores of Lake Tamagaminque. The deposits, which were only recently discovered, are immensely rich also in silver.

At first the owners of the deposits in Ontario did not trouble much about the cobalt, though this often amounted to as much as 18 per cent of the total, and it was regarded rather as a nuisance, as it interfered with the silver extraction. It soon became obvious, however, to the Canadian Department of Mines that cobalt had a new economic importance in view of its effect on steel. The director of the department, Dr. Eugene Haanel, therefore had an investigation made into the methods for preparing metallic cobalt from the oxide. The results of this investigation have recently been published, the necessary researches having been made at the School of Mining in Queen's University, Kingston, Ontario, in the course of which considerable quantities of pure metal were satisfactorily produced by one or other of the four methods adopted.

PREPARATION OF THE METAL.

These methods are all based on the reduction of commercial cobalt oxide, the reducing media in the four methods being, respectively, carbon, hydrogen gas, carbon monoxide gas, and aluminium. In the case of carbon, which is heated with the cobalt oxide in a crucible by electricity, it was found possible with a small laboratory plant to reduce enough oxide to make 56 pounds of the metal in an eight-hour day with the furnace absorbing 12 kilowatts. Thus, on a commercial basis, the power charge for effecting this reduction would be small. The hydrogen reduction experiments consisted in placing an alundum boat, containing a weighed amount of dried cobalt oxide, in an electric resister furnace, maintaining its temperature therein constant for a definite length of time, during which a stream of hydrogen was passed through the furnace. It was found that the reduction to metallic cobalt takes place very rapidly at all temperatures above 500 deg. Cent., and the method is especially recommended for the production of moderate quantities of very pure, carbon-free cobalt for special purposes, just as it has been used for the production of metallic tungsten.

The carbon monoxide experiments differed but little in general outline from the above, except in the nature of the gas. The reduction took place very quickly after a temperature of 600 deg. Cent. had been reached. Where producer-gas is available it should offer a cheap and efficient means of producing large quantities of pure metallic cobalt from the oxide.

The aluminium method of cobalt production is probably the most interesting, but hardly the cheapest, though it is practically essential when absolutely carbon-free metal is required. To effect the desired reduction, 5 to 10 pounds of finely divided cobalt oxide is mixed with powdered aluminium, and the whole placed in a conical welding furnace of the Thermit type. The reaction is started by lighting a fuse of finely divided aluminium and potassium chlorate rolled in a piece of tissue paper. The furnace fires with great violence and the contents are raised to a white heat.

The aluminium reduces the cobalt oxide, and oxide of aluminium is formed. One pound of aluminium will reduce and melt in this way two pounds of metallic cobalt. Therefore, there is a charge of about 9d in the form of one pound of metallic aluminium, for the power needed to reduce and melt two pounds of metallic cobalt. There might, of course, be some return for the fused aluminium oxide resulting from the process, but even allowing for this the costs are high compared with the carbon and carbon monoxide methods of reduction, to which reference has already been made.

It is obvious that the heating costs must be high by the aluminium method, for heat is being supplied at a temperature greater than 2,100 deg. Cent., that is at a temperature far in excess of what is required for the reduction of the oxide and the melting of the metal, and with consequent attendant increased losses, due to conduction and radiation.

The initiation of these investigations, as well as the thorough manner in which they were carried out, reflects great credit on the Canadian Department of Mines, and it is to be hoped that the enterprise will be rewarded by an ever-increasing demand for a metal of which the empire appears to possess unlimited supplies, and of which the use may be expected to grow rapidly, now that engineers are realizing the value of cobalt steels.

* *The London Daily Telegraph.*

Measurement of Short Intervals of Time

In conducting delicate scientific investigations it is frequently necessary to be able to measure very short intervals of time, or to be able to break two separate electric circuits in succession, but with a definite, predetermined interval of time that can be accurately controlled and reproduceable. How this can be done is explained by J. Coulson in the *Phys. Rev.*, 4 Ser. 2, P. 40, where he describes a simple apparatus that he has devised. The apparatus is based on the principle that if a massive weight, falling freely under gravity, strikes a collar on a metal rod which is supported vertically, an elastic wave or impulse travels out along the rod in each direction from the collar with a finite velocity. If the impact takes place at the middle of the rod, these waves will, of course, reach the ends of the rod at the same time. If, however, the point at which the impact occurs be not at the middle of the rod, the impulses will reach the ends at times that differ by an interval which will depend on the path-differences. In this way controllable time intervals extending over a considerable range may be secured, and can easily be measured with the aid of proper apparatus.

Gyroscopic Phenomena

A Popular Presentation of a Perplexing Phenomenon

By Bert L. Newkirk

THE useful applications of the gyroscope have become so numerous and so important, especially within the last two years, that well-informed men and women are asking for non-technical explanations of gyroscopic phenomena. The following is an analysis of the seemingly anomalous behavior of the gyroscope into three simple phenomena, with an effort to show that each is

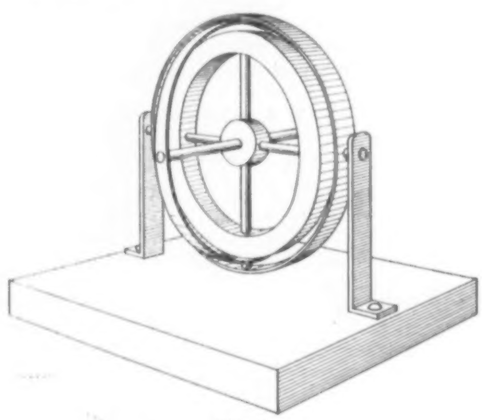


Fig. 1.

a perfectly natural occurrence, in full accord with every-day experience.

Any rapidly rotating body is a gyroscope, but a well-balanced wheel mounted in gimbal rings, as shown in Fig. 1, is best adapted to the present purpose. The mounting permits the axle to point in any direction and to turn about any line which passes through the center of the wheel. When the wheel is not spinning we may, by exerting a slight pressure with the fingers at the end of the axle cause it to move in various directions and assume positions as shown in Figs. 2 and 3. Naturally the end of the axle moves in the direction in which we push it, and it should move very easily, for the apparatus is worthless for demonstration unless the pivots about which the rings turn are nearly frictionless.

If now the wheel be made to spin rapidly and an effort be made to move the axle as before the apparatus will seem perverse. The most vigorous resistance will be offered to any attempt to change the direction of the axle. If we strike the end of the axle or the ring near it with a club or hammer we may use force enough to damage the mechanism without producing any considerable change in the direction of the axle. If we proceed more gently and exert a steady pressure as indicated in Figs. 2 and 3, motion will occur, but it will be mainly in a plane at right angles to that in which we push. The vigorous resistance and this seemingly anomalous motion are the two features of gyroscopic action that play the important roles in the useful applications. We call them *gyro-resistance* and *precession*. The last of the three phenomena mentioned above is the vibration or jar that occurs when the end of the axle or the ring near it is struck while the wheel is spinning. This jarring might seem to arise from the lack of rigidity of the mounting, and it is indeed very much like the vibration of a stiff spring; however, the effect is due to gyroscopic action and is called *nutation*. It takes the form of a very pronounced wobble if the end of the axle be given a quick push when the wheel is spinning at a slow rate.

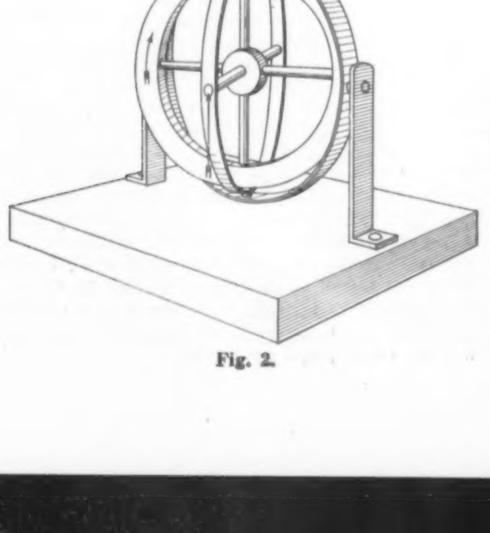


Fig. 2.

An example of the effect of gyro-resistance and precession is shown in Fig. 4. The axle is supported at one end and the weight of the body exerts a force tending to change the direction of the axle. Gyro-resistance prevents the fall of the wheel and frame and the precessional motion produced by the steady force of gravity occurs as indicated by the dotted line.

The common top, Fig. 5, offers another good illustration of the phenomena we are considering. The force of gravity, tending to overturn the top, is opposed by the gyro-resistance, and the precession occurs in a constantly changing direction, but always at right angles to the direction in which the top would fall if it were not spinning. The chattering of the top when it comes into contact with the wall while spinning is due to nutation.

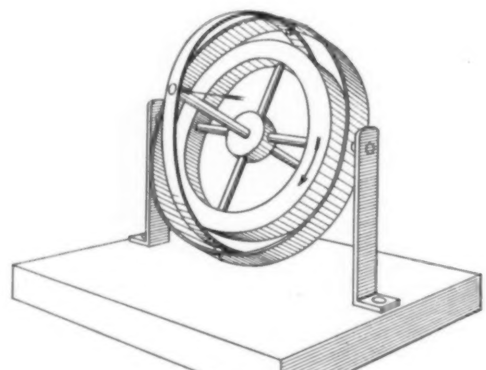


Fig. 3.

The phenomena described above are applied in the Brennan mono-rail car, the gyroscopic compass, a device to prevent the rolling of ships at sea, and in a number of other devices that play a more or less prominent part in human affairs. Especially worthy of mention, perhaps, is the fact that the dreaded submarine torpedo owes its effectiveness in large part to its gyroscopic steering mechanism.

I shall now attempt to show that these phenomena are perfectly natural and fully in accord with the facts of every-day experience. In the first place, since the phenomena appear only when the wheel is spinning, we conclude that the portion of the material which is

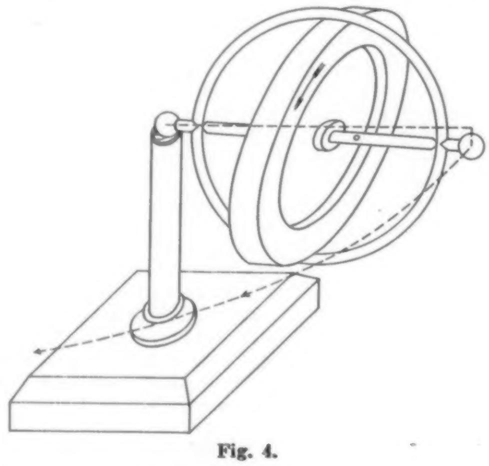


Fig. 4.

in rapid motion is responsible for the observed behavior. Second, since the rapidly moving material is almost entirely in the rim of the wheel, we look to that for the explanation. The forces which we apply at the end of the axle are transmitted by the spokes of the rim and there meet the resistance noted and produce the precession and nutation. Holding this fact in mind, let us stand at the near end of the axle (Fig. 1) with our eyes near the rim and looking toward it. Let us for the moment imagine the rim replaced by a series of separate bodies flying past our vision like bullets from a machine gun, each constrained to move in a circular path by a wire attached to some point below.

Now suppose that each of these bullets were struck a blow in the direction of the line of vision as it passes the eyes. The effect would be simply to deflect the stream slightly. The bullets, glancing off, would continue to move in circular paths as before, but in a slightly different plane. If the series of blows should cease as soon as each of the bullets had received one blow, then the whole series would be revolving in a plane slightly different from that in which they moved originally. Repeated series of blows would result in corresponding changes of the plane of motion. This is

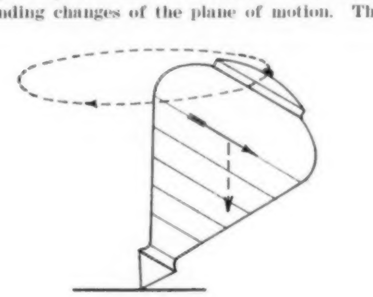


Fig. 5.

really precession. A lifting force, for example, exerted upon the end of an axle of a spinning wheel is carried by the spokes to the particles of the rim and acts upon them as the series of blows acts upon our stream of bullets. In both cases the result is a change in the plane of rotation. The bullets, though struck repeatedly in the direction indicated by the arrow, return always after completing a revolution to the point at which they were struck. Thus, the stream does not yield in the direction of the blows, just as the axle seems not to yield in the direction in which it is pushed. The resistance is gyro-resistance in both cases and the gyro-resistance seen from this point of view is only an example of the familiar resistance of streams of particles (water, for example) to any deflecting force. If a stream of water issuing from a nozzle under a high head be struck with a club, the club will rebound as though the stream were solid. (See Figs. 6 and 7.)

I have devised a simple apparatus to illustrate these effects. On account of the mechanical difficulty of causing a stream of bullets attached by wires to a central point to revolve rapidly without confusion, I have reduced the number to two and mounted them so as to balance each other and upon a universal joint so that they may revolve in any plane (Fig. 8). If these be set into rapid revolution in any plane and a heavy block of wood be held so that they will strike it a glancing blow as they pass a certain point in their path the result will be a gradual shifting of the plane of revolution, as explained above. The resistance which the revolving masses offer to the force exerted by the person holding the block illustrates the gyro-resistance.

We have disregarded the rigidity of the rim in thinking of it as a stream of bullets. Due to this rigidity, the lifting force impressed upon the end of the axle is not all imparted to the particles of the rim as they pass the highest point of the path, but it is exerted upon them continuously. The result is, however, precessional motion in either case. The rate of precession produced by a given force at the end of the axle of a wheel is the same as would be produced by an equivalent series of blows acting upon the rim or upon a stream of separate bodies of the same aggregate mass.

The nutational vibration or wobbling is a direct consequence of the rigidity of the wheel. For reasons to be explained below, the spinning wheel and axle do yield slightly to a force applied at the end of the axle. This yielding to the impressed force is called the dip. For example, if the rapidly spinning wheel of Fig. 4 is

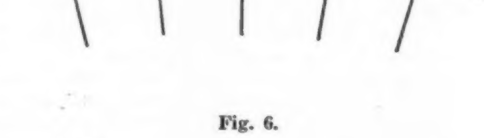
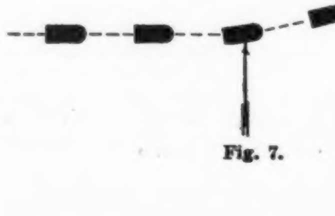


Fig. 6.



Viewed from above

Fig. 7.

placed upon the stand with the axle horizontal, and released, the wheel and frame will dip slightly into the position shown in the figure and precess so that the axle describes the surface of a cone of large angle. The illustration very much exaggerates the amount of the dip, which is usually so minute as to escape notice. When a wheel is spinning rapidly in gimbal mounting (Fig. 1) any force exerted to change the direction of

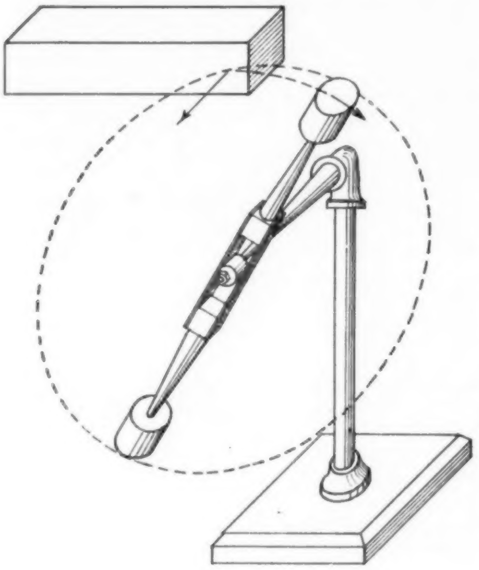


Fig. 8.

the axle will produce a slight dip in addition to the precession. This yielding or dip is very much like the yielding of a spring when stressed. If the wheel is spinning very rapidly it yields like a stiff spring, but if the spin is slow the yield is like that of a weak spring. The amount of the dip is very nearly proportional to the force applied.

The nutation is simply a fluctuation of the dip. When a load is suddenly dropped upon or hung from a spring there follows an oscillation, which dies out gradually. In a closely analagous manner a force suddenly applied to the end of the axle produces a dip of fluctuating magnitude, the oscillations gradually dying out, as in the case of the elastic vibrations. If the force be great, or if the wheel be spinning slowly, these nutational vibrations are conspicuously evident in the form of a wobble of the wheel, but more frequently they are noticeable only as a rattle or jar which disappears within a fraction of a second. The actual motion is a combination of the nutation with the precession. The wobble of a spent top is of this sort. A heavy gyroscope model in gimbal mounting will show it to advantage if the wheel be made to spin slowly and a weight be attached suddenly to one end of the axle.

Let us now inquire into the reason for the dip. If the rim were composed of separate sections like the series of bullets considered above, each would keep strictly to its path until it reached the top, when a sharp blow would produce a sudden deflection; but the wheel being in fact quite rigid, it is as though the single sharp blow which struck the bullet at one point in its path were replaced by a multitude of minute blows rained upon it during the whole course of a revolution. Consider a small section of the rim as it moves from A to B, Fig. 9. The upward force applied at the end of the axle begins at A, let us say, to produce a deflection, and continues to exert such an influence as the section moves forward, so that by the time it reaches B it is somewhat to the left of the position it would have occupied if the force were not acting. The whole circumference being acted upon in an analagous manner, the result is a slight tipping or yielding of the whole wheel to the force applied at the end of the axle.

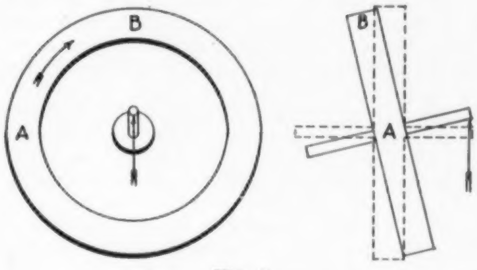


Fig. 9.

The three fundamental phenomena of gyroscopic action, namely, gyro-resistance, precession, and nutation, appear therefore as perfectly natural events thoroughly in accord with common experience as soon as we look to the rim of the wheel as the dominant part of the mechanism and remember that it is in rapid motion. The precession is a continuous deflection or "glancing off" of the particles composing the ring, the gyro-resistance is the resistance always encountered when a rapidly moving body is turned out of its course, and the nutation is the vibration which results from a blow or pressure suddenly applied to a yielding body.

Color Photography

While progress is being made in the technique of the production of colored photographs, the reproduction of photographs in natural colors, in the strict sense of the phrase, does not appear to advance. Yet the progress achieved in color photography must not be under-rated. Discoursing on "Color Photography," in two lectures delivered at the Royal Institution at recent meetings, Prof. W. J. Pope, F.R.S., of Cambridge, was able to exhibit many beautiful specimens, and to point out that the art is rendering valuable assistance to science. Dr. Pope confined himself to the general features of the problems, without entering into the chemistry of the processes and the intricacies of the technique. The problem of photography in natural colors presents itself under two aspects, that of the artist in black and white, and that of the color artist. With regard to the latter aspect, Prof. Pope pointed out, the difficulty was that the color appreciation of the eye differed from that of the photographic plate. The sensitiveness curve of the eye had a high peak in the yellow, and did not extend beyond the violet; the sensitiveness of the photographic plate was almost outside the range of the visual spectrum, and did not reach the yellow at all. Thus on a black-and-white photograph of daffodils the deep orange-yellow of the heart of the flower came out almost black, while the pale yellow of the petals appeared nearly white. Forty years ago Vogel had shown how the addition of certain coloring matters (sensitizers) to the emulsion of silver salts would render the plate more ortho-chromatic, and Abney and others had carried these studies further—so far, indeed, probably, as we could go in this direction. The sensitiveness curve of the panchromatic photographic plate now nearly embraced that of the human eye, but the peaks of the curves did not coincide; there was too much blue intensity in the photographic image. To correct this defect, Eder had interposed a yellow screen in front of the lens, which stopped the blue rays, and, with the aid of panchromatic plates and of color-filters, the effects of colors could now be reproduced in monochrome with fair fidelity.

The foundation upon which the reproduction was based had been given by Clerk Maxwell in the Royal Institution in 1861, though Maxwell's results, obtained so long before the days of ortho-chromatic plates, were poor. The principle was the three-color theory of Young-Helmholtz. The light had to be split up into its parts; each part had to be photographed separately, through screens of blue-violet, green, and red, and the positives had to be superposed. When light was sent (in the demonstration) through screens of these colors, and three disks in these colors projected, the overlapping three colors gave white, while the overlapping red and green gave yellow, the blue-violet and red together gave pink, and the blue-violet and green gave a sky-blue; these were additive color effects. But when light was sent through disks of glass stained with these latter complementary colors, or when disks were painted in the complementary colors, so as partly to overlap again, the three colors together gave black, the sky-blue and yellow gave green, the pink and sky-blue gave blue-violet, and the yellow and pink gave red; those were "subtractive" effects. White light sent through transparent screens of the colors in the last instance would, of course, appear in the complementary colors, and the black spot would shut out all the light and would, therefore, appear white on the negative. To work on this principle complicated cameras provided with three lenses were not needed; a plate was exposed behind each of the filters in a camera, as it would indeed be difficul to use one camera with three lenses, since the three negatives would not be taken from exactly the same spot, and would not quite coincide, therefore. Transparencies from the three negatives were illuminated by their own colors (i. e., the photograph taken through a red screen was illuminated by the light through the same red screen) and superposed. But when prints made from these negatives were to be superposed they had first to be colored in the complementary colors.

The Du Hauron, Ives, Sanger-Shepherd, and other processes were based upon this principle; they gave excellent results, but the superposition required very great care. Hence other processes had been tried.

Nearly 20 years ago Prof. Joly, of Dublin, introduced a new method. He ruled a glass plate with a series of parallel lines, red, green, and blue, repeating the colors in the same sequence all over the plate or screen, which was then divided into fine stripes of colors. This screen was put in front of the plate when the photograph was taken, and when the contact transparency from the negative was examined through a screen in complementary colors, the colors came out very well, especially the whites; the greens were less satisfactory. On the original plates of Joly, exhibited by Dr. Pope, the greens were bad; but with modern screens, which were ruled in very fine lines and fitted with means for securing an excellent register, artistic effects were realized. The horizontal or vertical stripes were faintly visible, however, in the magnified projected lantern images, unless the focussing was intentionally spoiled to a slight extent. The stripes could successfully be replaced by squares in the three colors; but the exact registering remained a difficulty.

The autochrome process disposed of this difficulty. In these the screen was permanently attached to the photographic panchromatic film, and remained in contact with it all through the photographic process. For the strips or squares or regular geometrical patterns of the former processes, grains grains, dyed in the three colors, were substituted. The grains, dyed red, green, and blue-violet, and properly mixed, were uniformly distributed over the glass plate, rolled into some adhesive substance, dried, and then coated with the photographic film. The plate consisted of very small patches of red, green, and blue. The plate itself looked whitish; the magnified projection showed the colored patches in irregular arrangement. On exposure, light would pass through the glass front, through the starch grains on to the sensitized film. Only red light would pass through a red grain, the other light being stopped. Silver would therefore be deposited under the red patch, corresponding to a red spot in the object, and the spot would appear dark and opaque after development. When this negative was held up to the light, little color would be visible, because the rays would now be stopped by the deposited silver; this silver had hence to be removed and reversal effected. The negative would then be exposed to light to produce a positive, which was again developed, and the color showed clearly after the second development. Each photograph gave only one print, however. Photographs of flowers, scenery, portraits in gay colors, reproductions of classical pictures, etc., were exhibited to show the beautiful effects realizable by this process. On the white parts of the images some colored spots could generally be distinguished by close examination, even in the not-magnified mirror images of transparencies. On the other hand, the gloss of the hair and the iridescence of butterfly wings were reproduced with remarkable fidelity, though the iridescence might not emanate from the same spot in the original (shown by the aid of an epidiascope) and the photographs, since the angles of the incidence of light were not the same. Prof. Pope drew particular attention to his photographs, obtained by the various processes alluded to, of pathological objects and of microscopic sections of rocks and crystals taken between nicol prisms in polarized light. That the colors of the stained pathological preparations were not always quite faithful did not matter so much, because the chief point was, of course, to bring out and to fix for future re-examination all the details revealed by the microscope. The amazing complexity of rocks, like granite, dolerite, etc., was fully brought out by polarized light in all its brilliancy of colors.

Leaving technical details to some future occasion, Prof. Pope mentioned in his conclusion the attempts made to do without colored screens of any kind. Prof. Wood had obtained some success with gratings. When the diffraction spectrum of a grating was looked at in a particular direction, some particular color was seen, which depended upon the incidence and on the fineness of the ruling. When three pictures were taken through gratings of three different degrees of fineness of ruling, colored photographs could be obtained; they were not suited for projection by the lantern, but only for individual examination. This method might be perfected.

A further development in photographic color processes was exhibited at the Royal Photographic Society on Tuesday last. It is known as the Kodachrome process, and consists in making two negatives of a subject through red and green light filters; the plates, after development, are bleached and stained, the one with a red dye, and the other with a green color. The plates thus obtained are clamped together and viewed as a transparency, very beautiful results being obtained.—*Engineering*.

Benzole is very extensively used as fuel for the motor transports of the German army, and immense quantities are required. It is reported that the Association of German Benzole Manufacturers of Bochum has contracted with the government for the whole of its requirements. In the Dortmund district it is said the coke ovens are still producing 5,400 tons of benzole a month.

Tides in the Earth's Crust*

And the Elasticity of the Globe

By Alphonse Berget

When we study in detail the movements to which the earth is subject, we are astonished at their number and diversity. Apart from its rotation around its axis and its revolution in an elliptical orbit around the sun, the earth is subject to other movements, the more important of which are the precession of the equinoxes and nutation. It has recently been discovered that the terrestrial poles are not fixed within the earth, but undergo displacements of the order of magnitude of the tenth of a second of arc; moreover, the solar system as a whole, including of course the earth, is moving through the heavens in the direction of the star Vega, at a speed of about 12 miles a second. Thus there are, altogether, six movements to which the earth is subject.

In the study of these six movements, however, we suppose the earth's crust itself to be rigid and to preserve perpetually the form of a flattened ellipsoid imposed upon it by universal attraction and the centrifugal force due to its movement of rotation.

Nevertheless the question arises whether this assumption is correct; i. e., whether the crust of the earth does not itself undergo periodic deformations, and, if it does, under what influences these deformations are brought about. Lord Kelvin was the first to investigate the "elasticity of the earth," and to place before the world the question whether the earth's crust does not constitute an elastic body the shape of which is continually modified by external forces, the principal of these being the attractions of the moon and the sun, which, as is well known, produce in the ocean the phenomenon of the tides. In a word, does not the terrestrial crust have its own tides, which periodically alter its form? Such is the question to be considered.

The attraction exercised by the moon and the sun on any movable body on the earth's surface, such, for example, as the bob of a plumb-line, in a state of rest, varies continually in magnitude and direction with the position of these two bodies with respect to the earth. The prolongation of the plumb-line should, therefore, describe a certain curve on a sheet of paper fixed beneath it on the ground. Hence the question resolves itself into one of "deflections of the vertical." Let us try to calculate this "lunisolar" attraction. At first thought one might suppose it to be considerable. The mass of the sun is about 325,000 times as great as that of the earth, while its distance from the earth is equivalent to 23,400 times the terrestrial radius. Computing the attraction, according to Newton's law, as proportional to the masses and in inverse ratio to the square of the distance, we find for the deflecting force acting on the plumb-line the equivalent of about 1/1300 the force of gravity. From this it would seem that the solar attraction causes in bodies on the earth an apparent loss of weight equal to 1/1300 of their weight.

This simple reasoning is, however, erroneous. We must not forget that the earth itself performs essential movements under this same solar attraction, in describing its elliptical orbit around the luminary. Now it is a fundamental principle in mechanics that a force once obeyed enters no further into the calculation unless allowance is made for the effect already produced by it. A heavy body suspended over the earth's surface and drawn away from the vertical by the sun's attraction moves along with the earth itself in response to this attraction. Hence there remains as a force effective in disturbing the vertical, only the difference between the attraction exercised at the surface and that exercised at the center of the earth. Calculating on this basis, the figure obtained is, for the solar attraction, only about 1/20,000 of that obtained in the previous calculation, and represents only the 26-millionth part of the force of gravity.

Let us now consider the attraction of the moon. The small mass of our satellite, which is only the eightieth part of that of the earth, is largely compensated, with respect to its attraction upon terrestrial bodies, by its comparatively small distance, for the center of the moon is distant from the center of the earth only thirty diameters of the latter. Making the same calculations for the attraction of the moon that we have just made for that of the sun, we find the perturbation in the weight of terrestrial bodies due to the attraction of our satellite to be about 1/12,000,000.

To the French astronomer, Victor Puiseux, we owe the first analytical study of this perturbative action. The astronomer Gaillot subsequently gave us a simplified form of the analysis and traced the theoretical curves which should be described on a horizontal sheet of paper by the prolongation of a plumb-line under the influence of lunar attraction, assuming an absolutely rigid earth. These curves are reproduced in the accompanying four figures, which shows the different forms of the curve corresponding to different values of the moon's declination. (Figs. 1, 2, 3, 4.)

Fig.1 – (Δ = 0)

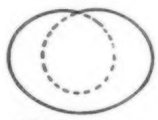


Fig. 2 – (Δ = 10°)

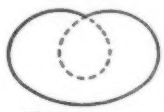


Fig 3 – (Δ = 20°)

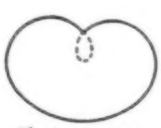


Fig. 4 – (Δ = 30°)

When these calculations were made known, many investigators were discouraged by the revelation of the minute effect to be measured. At the end of a plumb-line 100 meters long, an instrument which would itself be difficult to install under suitable conditions of stability, the deflection would be only about a hundredth of a millimeter. This easily explains the failure which attended the efforts of such physicists as Lord Kelvin in 1878, Bouquet de la Grye in 1874, G. and H. Darwin in 1879, d'Abbadie in 1881, and Ch. Wolf in 1883, to make direct measurements.

There is, however, another cause for the failure of such attempts, and this arises from the elasticity of the terrestrial globe. The calculations serving as points of departure in all the experiments above mentioned were made on the hypothesis that the earth is an undeformable sphere and absolutely rigid. The situation is completely changed if we suppose the earth to possess a certain elasticity which enables it to undergo deformations in obedience to the lunisolar attractions. The earth's crust would then behave like the water which forms the free surface of the sea: a protuberance would be formed and the crust would be subject to true tides.

It must, on the other hand, be stated at once that the deformations produced in the earth by the two celestial bodies in question may be essentially different in nature; some of them act only on the superficial layers of the earth, while others act on the whole globe. In the former case they produce an *apparent* deflection of the vertical, for, in reality, it is the surface layers themselves which, affected by these deformations, are displaced with respect to the vertical, while the latter remains unchanged. The principal reason for these apparent deflections is the heating of the external layers of the earth's crust by the sun's rays. The solid crust of rock enveloping the earth is a poor conductor of heat. Hence only the part of the earth turned toward the sun feels the warming influence of the solar rays, which expand and deform it, while the opposite side of the globe is heated and deformed in its turn twelve hours later. Moreover, also on account of the poor conductive properties of the earth, the distortions caused by surface heating do not extend to a great depth. Since the heat of the sun is the principal cause of these apparent deflections, it follows that the latter must have a periodicity analogous to that of the solar movements; i. e., a diurnal period. On this will be superposed an annual period, due to the variation in the obliquity of the solar rays with the march of the seasons, which, in turn, depends upon the variation in the sun's declination.

But there are also real, as well as apparent, deflections of the vertical, and their cause is to be sought, not in local heating under the influence of the sun's rays, but in the attractions exercised by the moon and sun upon the matter constituting the whole globe. If the latter were rigid, the lunar and solar attraction could not produce any deformation in it, and the deflections of the vertical could be calculated by the methods above described. If, on the other hand, the terrestrial globe were wholly fluid, and if, accordingly, it behaved like a liquid and non-viscous sphere, the outer surface, like that of the ocean, would change its shape every moment under the attractions of the sun and the moon. Under such conditions the physical observation of the deflection of the vertical would be impossible; since, by definition, the vertical is always a line perpendicular to the surface of the ground. Moreover, it would be impossible to observe the terrestrial tide, owing to the lack of any fixed point of comparison. For the same reason the oceanic tide cannot be observed in the open sea, far from any shore.

Fortunately the truth lies between these two extremes; the earth is neither absolutely rigid nor absolutely fluid. Nevertheless, although it does not possess absolute rigidity, it has a considerable degree of "solidity." The state in which matter must find itself in the liquid central core of the earth, where it is subjected to colossal pressure, implies a compactness nearly akin to solidity. Basing his calculations on the known values of the precession of the equinoxes and nutation, Lord Kelvin was led to conclude that, considered as a whole, the earth must possess a rigidity comparable to that of steel. Hence we must admit that our globe, as a whole, is endowed with a certain degree of elasticity.

In virtue of this elasticity the shape of the globe must be modified every moment by the combined attractions of the sun and moon, at the same time that it undergoes local superficial deformations for the reasons above mentioned. Consequently, the deflection to be observed in the direction of the plumb line will be the difference between these two effects. The delicacy of the observation explains the ill-success attending earlier efforts to measure this deflection. However, some experiments of high precision executed in the laboratory of the International Geodetic Association have successfully put in evidence, not only qualitatively but also quantitatively, the deflection of the vertical. These experiments made use of an indirect method, based upon the prodigious sensitiveness of the instrument known as the horizontal pendulum.

The horizontal pendulum consists essentially of a horizontal rod fixed to a solid metal support by two vertical wires. The points of attachment of these two wires are not in the same vertical line, but in two vertical lines which can be shifted with respect to each other at will. The free extremity of the horizontal boom carries a weight to which is affixed a mirror, which, by reflecting a ray of light, serves to register the slightest displacements of the weight on a strip of sensitive photographic paper arranged to be unrolled by clockwork.

The apparatus being thus arranged and its support resting on a horizontal plane, the pendulum assumes a position of equilibrium, and this position is absolutely fixed for a given direction of the vertical. If, however, the latter becomes deflected, even in the slightest degree, the pendulum begins to oscillate. The law of its oscillation is, moreover, simple; its duration is the same as that of a vertical pendulum having a length equivalent to the vertical distance between the weight and the point where the straight line joining the points of attachment of the two wires, intersects the vertical line passing through the center of gravity of the oscillating weight. Evidently we may make this length as great as desired by shifting the points of attachment of the two wires that support the pendulum toward each other horizontally. Thus we have a horizontal pendulum oscillating as slowly as a vertical pendulum of great length.

The experiments just mentioned utilized two of these horizontal pendulums, the booms of which, in their positions of equilibrium, were at right angles to each other. The distance between the points of attachment in the two cases were such as to correspond, respectively, as measured by their oscillations, to ordinary pendulums 175 and 117 meters long. The two booms were oriented symmetrically with respect to the

* Translated for the Scientific American Supplement from *Larousse mensuel*.

meridian of the place of observation, and their oscillations were recorded by the photographic device described above. Comparing the graphs thus obtained, and constructing, point by point, curves having for abscissas and ordinates the results deduced from the movements of the two pendulums, a curve was obtained which represents the displacements which would actually occur in the end of a plumb line under the effect of the lunisolar attractions. This curve was constructed for each day, and the results were grouped in periods of ninety days to give trimonthly means.

By this means it was possible to observe the existence of a deflection of the vertical in the direction of the meridian amounting to one-five hundredth of a second of arc. Moreover the trimonthly means showed the amplitude of the oscillation to be only half as great in Winter as in Summer. Thus we are clearly confronted with thermal effects, the cause of which is, as foreseen, the superficial heating of the ground by the rays of the sun. The effects of such dilatation mask completely those of the lunisolar attraction upon the pendulum.

It has been possible, however, to find observational evidence of the latter, by taking account of an essential fact. The period of thermal action is twenty-four hours, or diurnal, while that of the attractive action of the sun is twelve hours, or semidiurnal. This follows from the fact that the solar attraction is exercised in the same manner when the sun occupies either of two symmetrical positions with respect to a given diameter of the earth, and this occurs twice in twenty-four hours. By combining, two by two, the values of the deflections for each hour, and taking half the sum and half the difference of each pair, we obtain the desired result; for, in the half-sum, the thermal effect is naturally eliminated, since it is equal but of opposite sign for the two hours in question, while the attractive effect remains unaffected. On the other hand, the thermal effect is given by the half-difference, while the attractive effect disappears. In computing the lunar action, the separation of the two effects is easier, owing to the difference of period; the lunar period is 24 hours 50 minutes, as compared with the 24-hour period of the sun which gives the thermal effect.

One cannot but be struck by the similarity of "observed" curves to those calculated by Gaillot. There is, however, a slight difference between the two sorts of curves. The observed curves have a smaller amplitude than the theoretical curves, and this diminution of amplitude is about half as great in the direction of the meridian as in that of the parallel. The closed loop seen in the curves corresponding to high northern declination of the moon is due to the fact that the lunar tidal wave has two daily maxima; these maxima are equal if the moon lies in the plane of the equator, unequal if it lies north or south of it; and the further our satellite lies from the equatorial plane, the more pronounced is the inequality.

The conclusion to be deduced from these admirable experiments is quite definite: Our earth, considered as a whole, possesses a certain elasticity, of the same order of magnitude as that of steel; i. e., as to the deformations it undergoes, the globe behaves nearly the same as would a globe of steel of the same dimensions. It is most interesting to find that a consideration of the oceanic tides, the migrations of the terrestrial poles, and the precessional and nutational movements of the earth all lead us to assign to the globe a general elasticity of about the same order. This is a remarkable confirmation of the early ideas of Lord Kelvin.

The study of seismic phenomena leads us to an analogous conclusion. The original shocks which give rise to earthquakes are, indeed, transmitted in two different ways; viz., through the crust, and through the terrestrial spheroid as a whole. The propagation through the crust takes place at various speeds according to the nature of the material, and ranges between 150 and 800 meters per second. The latter speed is seldom exceeded. It is these movements in the crust that cause the folds and crevasses often observed after seismic phenomena of great intensity. On the other hand, the propagation of the same shocks through the globe as a whole takes place much more rapidly. When a strong earthquake occurs at any point on the earth, the most remote seismological observatories—distant, for example, 6,000 to 8,000 kilometers from the epicenter—are notified of it within a few minutes by the disturbance of their seismographs. Comparing the time of such registration with the actual time of occurrence at the point of origin, and taking account of the distance, we find that the propagation of the shock through the earth takes place at a speed of 10 kilometers per second; i. e., about 500 times the speed of an express train.

After the first registration, it is found that, at the end of some minutes, the seismographs begin to be disturbed and to register again. If, as in the previous case, we compare the time of this second registration with that at which the phenomenon really occurred, we find that these new seismic waves have traveled with a speed which is, in this case, not 10 but 5 kilometers per seconds; i. e., half the speed of the former series. Now the mathematical theory of elasticity furnishes a remarkable check on these observations. This theory, which, it should be remembered, is based on laboratory experiments, teaches us that if a sudden shock occurs at any point in an elastic sphere it will be transmitted to the whole mass in the form of waves. Moreover, the shock gives rise to two distinct series of waves, of which one series is transmitted at twice the speed of the other.

This is exactly what our observations show in the case of seismic shocks transmitted through the terrestrial globe as a whole. Moreover, if we introduce into our formula for elasticity the data of seismological observations, the unknown quantity being the general elasticity of the earth, we find for the latter a numerical value of the same order of magnitude as that of steel. Here we have a magnificent confirmation of the theory of elasticity, and an admirable agreement with the results obtained by other methods.

Thus it is possible for us to form a tolerably correct idea concerning the state of the igneous matters constituting the central core of the earth. Taking account of the "geothermic degree," i. e., the increase of temperature amounting, on the average, to 3 degrees per 100 meters, which prevails with increase of distance from the surface of the earth, science has been led to assign to the earth's crust a limiting thickness of from 60 to 70 kilometers, or about a hundredth part of the radius of the earth. Below this crust there must be materials the relatively high density of which compensates for the relatively low density of the surface rocks, with a specific density of about 2.5, in order that the general density of the earth may attain the density of 5.5 which it is known to possess. The density of the matter at the center must be approximately 10, and only the metals possess densities of this order. Hence the central core is composed of mainly metallic and ferruginous materials in a state of fusion, and at a temperature far above their melting-points.

How, then, shall we reconcile the liquid state resulting from fusion with the elasticity of the globe, which we have found to be comparable to that of steel?

It is only necessary, as Lapparent has pointed out, to consider the enormous pressures to which the materials constituting the core of the earth are subjected. If the earth were entirely composed of water the pressure at the center would be more than 600,000 atmospheres. As its density is 5½ times that of water, the pressure at the center must be more than 3,000,000 atmospheres. Now we cannot, from our laboratory experiments, the most daring of which have hardly attained pressures of a few thousand atmospheres, form any idea as to what may be the condition of metals, melted, it is true, but subjected to pressures of several million atmospheres. It is probable that the formidable compression to which these materials are subjected gives them a rigidity "practically equivalent to the solid state." Thus we explain the elasticity, analogous to that of steel, presented by our globe as a whole.

Camp Engineering—Water Purification

We hear so much of the work of mechanical and electrical engineers in connection with the war that that of civil engineers does not always receive the appreciation it deserves.

Yet, where would our brave troops be, at home and abroad, if they were deprived of the results of the skilled efforts made on their behalf by untiring engineers to insure that their camps are well placed and are sanitary; their water supplies good (if not always as ample as might be desired); and their communications—in the shape of roads and bridges—properly maintained?

Large numbers of highly-trained municipal, civil, and other engineers have gone to the front, or to the many camps up and down the country, there to give of the best of their technical knowledge and experience, in order that this may help to make the life of their comrades in arms safer, pleasanter, and more comfortable in every way.

How our soldiers are provided in certain cases with suitable supplies of drinking water is an interesting and important consideration. If a town supply be available the problem is, of course, a simple one, it merely being necessary to lay pipes of adequate section after making sure, by bacteriological examination, that the quality of the intended supply is above suspicion. Very frequently, however, a camp has to depend for its water supply on a river or a lake. In such a case the construction of filters is a first necessity. For this purpose barrels filled with filtering media are often employed. Over the bottom of one of a pair of barrels, connected at their lowest level by a short piece of pipe, a perforated metal plate is fixed, and resting on this, in evenly spaced layers one above the other, is charcoal, coarse sand, and gravel, respectively, the unfiltered water being poured or pumped on to the surface of the latter, which is a foot or so below the edge of the barrel. After percolating through the various layers the water, now considerably purified, passes through the connecting pipe to the second barrel, where, in its upward passage, it encounters succesively layers of coarse sand, charcoal, and gravel, from the latter of which it emerges free from all matter in suspension, and ready to be drawn off at the top of the barrel for drinking or culinary purposes. It is assumed, of course, that the water did not originally contain any disease germs, which, naturally, cannot be removed by filtration, though subsequent boiling is generally efficacious as a germicidal process.

In camp the position of the supplies of water for men and horses is usually indicated by colored flags; thus, white means drinking water for men, and blue for horses, while doubtful water (suitable perhaps for washing purposes) is marked green, red indicating polluted water.

The locality of a camp is a matter for the General Staff to decide, but in choosing its exact position the engineer might well be consulted. He could indicate, with his knowledge of subsoils, the driest spot in the vicinity that was available. He would also see that the mechanical transport vehicles were parked in as good a place as could be found, and were not allotted some out-of-the-way marshy field, where there would be constant trouble occasioned at starting, and by the sinking in of vehicles. Good roads are a necessity to any camp, and here we may say what a boom has been the *pavé* of northern France and Belgium. In times of peace power-driven vehicles avoid these paved roads, with their shockingly uneven surfaces like the plague, all road maps marking *pavé* very clearly, so that it can easily be avoided. But in winter warfare these paved roads, built on this system from time immemorial, are a boon; for though they do have a decidedly bad effect, owing to their irregular contour, on the machinery of the heavy vehicles using them they enable progress to be made, whereas, but for them, transit would have to be conducted through a quagmire. This is often the case even now on roads leading up to the front and to large camps and stores depots, for the *pavé* is usually only wide enough for one vehicle, hence when troops or vehicles coming in an opposite direction are passed the unpaved side of the road has to be used—often with disastrous results. Engineers are therefore now at work on many such roads extending the *pavé*, so that two streams of traffic can pass without difficulty.—*The London Daily Telegraph.*

Electrification of Water by Splashing and Spraying

In the *Proceedings* of the Royal Society, Ser. 790, p. 531, J. J. Nolan endeavors to establish a connection between the charge produced on a sprayed liquid and the extent to which it has been broken up. The liquid used is distilled water, and two methods are described for breaking it up in contact with the air: (1) by splashing against an air-blast, (2) by spraying. In the first method drops are allowed to fall into a strong horizontal air current. Each drop is shattered by the blast into a number of varying size, and a rough sorting out is effected as the bigger drops are carried further aside by the blast. The drops chiefly used are the fine ones which enter a measuring vessel placed directly under the dropper, as these are fairly uniform in size. Variations in size can be obtained by altering the height of the dropper or the strength of the air-blast. In the second method an ordinary scent spray is used to form the drops. Measurements are made of the charge carried to the receiving vessel, the volume of water, and the number of drops which enter it (giving the mean size of the drops). It is found that the charge, E, per centimeter^2 of water increases with a decrease in the radius r of the drop. $E = k/r$ where k is a constant. This result is explained simply, on the assumption that the charge on the water is proportional to the area of new water surface created when the drops are formed. Both methods give good agreement in the value of the constant. The air drawn from the sprayer was examined to find how the negative charge is carried and it was found that the air contained a number of ions of both signs (excess of negative), ranging in mobility from the large ion found by Langevin to the ordinary atmospheric ion. **It is probable that the excess of negative charge in the air is present mainly as small ions.**

NEW BOOKS, ETC.

THE LAW OF CARRIERS OF GOODS. By Ralph Merriam, of the Chicago Bar. Chicago: LaSalle Extension University, 1914. 8vo.; 180 pp.

THE ACT TO REGULATE COMMERCE. And Supplemental Acts. By Herbert C. Lust, of the Chicago Bar. Chicago: LaSalle Extension University, 1915. 8vo.; 141 pp.

In the first of these text-books the rather peculiar liability of the common carrier is made clear and, without attempting to trace exhaustively the maze of legal situations that emerge from this nucleus, the law and its elementary principles are closely detailed, and the student is instructed in the analysis and application of court decisions. In the second text the Act to Regulate Commerce, as amended, and sundry acts directly bearing upon the same subject, are presented in full, while the main body of the work expounds the terms and applications of this legislation and appends a series of test questions well adapted to disclose the knowledge—or display the ignorance—of the student. Both texts continue the expert and thorough work for which the course in interstate commerce and railway traffic must be ungrudgingly commended.

FIELD PRACTICE. An inspection Manual for Property Owners, Fire Departments and Inspection Offices. Boston: National Fire Protection Association, 1914. 16mo.; 199 pp.; illustrated. Price, $1.50.

Designed as an official handbook for all who are vitally interested in fire prevention, this convenient little volume deals with common fire hazards, their safeguarding, and the upkeep of protective devices and installations. It includes suggestions toward the safe handling of chemicals, paints and oils, and discusses spontaneous ignition, dust explosions, chimneys and flues, and dwelling house hazards. The second part of the work imparts much information as to automatic sprinkling installations and fire protection in general. The efficient carrying out of its simple instructions would mean a very appreciable diminution in fire loss.

HANCOCK'S APPLIED MECHANICS FOR ENGINEERS. Revised and Rewritten by N. C. Riggs, Professor of Theoretical and Applied Mechanics in the School of Applied Science of the Carnegie Institute of Technology. New York: The Macmillan Company, 1915. 8vo.; 441 pp.; illustrated. Price, $2.40.

This is a text for students of the junior year, providing work for one semester, although the number of problems are in excess of this requirement. The title indicates, and the text realizes, the author's aim to make of problems in mechanics practical engineering work. The universal difficulty experienced by the student when he first endeavors to put theory into practice is met by following the development of each new principle by numerous applications. Into these applications much new material has been introduced. Particularly gratifying results in this direction are to be noted in the chapters on moment of inertia, center of gravity, work and energy, and friction and impact.

OUT OF WORK. A Study of Unemployment. By Frances A. Kellor, editor of "Immigrants in America Review." New York: G. P. Putnam's Sons, 1915. 8vo.; 569 pp. Price, $1.50 net.

"Out of Work" thoroughly acquaints the reader with the present machinery of employment, both private and governmental, and pitilessly discloses its imperfections and its inadequacy. It exposes, also, the fallacies of complacency, which assume that a man can always get work of some kind; that snow shoveling and farm labor provide means of existence for the willing worker; and that unemployment is, in short, a moral rather than an industrial problem. There is no deliberate emotional appeal, but the bare statement of undeniable facts is sufficient to touch the heart and quicken the intelligence toward organized effort in the direction of bettering conditions. Much of the existing evil might be obviated by the adoption of methods indicated by the author, whose work delves to the primary causes of industrial distress and efficiently grapples with conditions, the evil of which can scarcely be exaggerated, and which the more favored individual but vaguely appreciates. The volume comprises a practical study, not an academical discussion, and bears internal evidence of first-hand knowledge, organized reasoning, and logical conclusions.

500 PLAIN ANSWERS TO DIRECT QUESTIONS ON STEAM, HOT WATER, VAPOR AND VACUUM HEATING. By Alfred G. King. New York: The Norman W. Henley Publishing Company, 1915. 8vo.; 214 pp.; illustrated. Price, $1.50.

All furnace heating systems and their problems are here dealt with in the form of questions and answers. When and why should a chimney be built round? When square? What is the thermostatic principle? What are the purposes of an equalizing pipe? What is a non-mechanical system of vacuum heating? These questions indicate the scope of the work, which distinctly tells the how and the why in terms that all may understand. It has value both as a text-book and as a reference book, and will prove particularly useful to any who are preparing to take examinations. It is not sparing of its diagrams, and many tables and formulas germane to the subject of heating are included.

A DOCTOR'S VIEWPOINT. By John Bessner Huber, A.M., M.D. New York: Gazette Publishing Company, 1914. 12mo.; 164 pp.

The first paper of this collection, "A Twentieth Century Epic," is a really fine tribute to preventive medicine, with an appreciation of some of our medical martyrs and an intense sketch of the achievements of Gorgas in Panama. The other papers are more in the nature of commonsense talks on prevalent infirmities—little dishes of wit, wisdom, and folly, in which the wisdom generally manages to predominate to the distinct benefit of the reader.

THE AMERICAN INDIAN IN THE UNITED STATES. Period 1850-1914. By Warren K. Moorehead, A.M. Andover, Mass.: The Andover Press, 1914. 4to.; 440 pp.; illustrated.

It is the author's belief that, in spite of the flood of popular literature relating to the Indian, he is still not properly understood. The work in hand seeks to present truthfully and comprehensively, so far as any study of human character may be comprehensive, the Indian of to-day, his traits, activities and tendencies, and the critical situation that confronts him. In the necessity of selecting the most significant facts from the wealth of available material, the author faced a difficult task, in which he has acquitted himself well. He skillfully blends the scientist's and the humanitarian's points of view. The result is an unusually accurate picture of the present-day Indian, with the influences both good and bad that have modified so materially his character and his outlook. The scandals of the reservations are bared, and a plea for justice is made. Good maps and illustrations add to the value of the work, which is avowedly but the first volume of a series by the same author, designed to treat adequately the American Indian of the present and the past.

JESUS AND POLITICS. An Essay Towards an Ideal. By Harold B. Shepheard, M.A. New York: E. P. Dutton & Co., 1915. 12mo.; 145 pp. Price, $1 net.

It has been the author's aim to show the compatibility of Christianity and politics, the futility of politics without the church, and the sterility of the church without politics. There is much nobility of thought and a certain passionate sincerity in the volume, but it is unfortunate that the discourse is after all more in the nature of rhapsody than of convincingly-marshalled argument. This narrows its appeal to those already favorable to its tenets, and repels minds that are most in need of the leaven of its sentiment.

SCIENTIFIC FEEDING. By Mrs. Dora C. C. L. Roper, D.O. Oakland, Cal.: Published by the Author. 12mo.; 267 pp. Price, $1.65 net.

"Scientific Feeding" contains valuable suggestion and instruction, together with some unorthodox, even dubious, teaching. It embraces the classification and function of foods, and their preparation and combination. There are sample menus, with given caloric value, for the average adult and for the aged. Diet during pregnancy, the care and feeding of children, and breakfast, dinner, and supper menus, are discussed under food requirements. A "poor man's bill of fare" would call forth from most people the sympathetic exclamation, "Poor man indeed!"—and it seems as if more tasteful and substantial items might have been included, even under the lowest allowances. The bills are, however, varied and suggestive. A following section aims at the prevention and cure of disease, mainly by dietary correction. The author does not sufficiently recognize the fact that, although one man's meat may not literally be another's poison, the personal equation and acquired tastes play an important part in the result. The work should be read for inspiration and suggestion, rather than regarded as a perfected plan to be slavishly followed.

ESSENTIALS OF ENGLISH SPEECH AND LITERATURE. An Outline of the Origin and Growth of the Language, with Chapters on the Influence of the Bible, the Value of the Dictionary, and the Use of the Grammar in the Study of the English Tongue. By Frank H. Vizetelly, Litt.D., LL.D. New York: Funk & Wagnalls Company, 1915. 12mo.; 408 pp. Price, $1.50 net.

In an exceptionally well-arranged exposition, Dr. Vizetelly sets forth the origin of our language, its orthographical development, and the influences that have made it the plastic and efficient medium it is to-day. He specifically directs attention to mutations in orthography and syntax, bringing this investigation down to present usage. The conspectus includes chapters on the influence of the Bible, on the drama and the periodical press; it explains the functions of the grammar and the dictionary, and emphasizes the benefits deriving from a study of both. The volume is of necessity selective rather than exhaustive, and it is in this selective process and in the general arrangement of his material that the author shows his keen judgment and his unobtrusive erudition. There is nothing more fascinating and at the same time more broadening than a study of the language and literature of a race, and the work in hand is entirely successful in conveying a great amount of information and instruction in a compact and appealing form.

THE PRACTICAL LUMBERMAN. Third Edition. By Bernard Brereton. Tacoma, Washington: Published by the Author. 16mo.; 256 pp.; illustrated. Price, $1.50.

"The Practical Lumberman" is a little book giving brief descriptions of the commercially most important woods of the Pacific Coast, with the color and grain of the manufactured product, the various ways of distinguishing merchantable grades, the shrinkage, the weight and strength, the many uses to which each wood is put, and other facts equally to the point. Short methods of figuring lumber are given. All the information of the little handbook is of value to both buyer and seller, and is so compactly presented that the volume will not overburden the ordinary coat pocket.

ELECTRICITY FOR THE FARM. Light, Heat and Power by Inexpensive Methods from the Water Wheel or Farm Engine. By Frederick Irving Anderson. New York: The Macmillan Company, 1915. 12mo.; 265 pp.; illustrated. Price, $1.25.

In an Aladdin-like story of a farmer who returns one dark night from a vacation, to find his home and the outbuildings flooded with bright light at the touch of a button, we are shown the contrast between the old-style lighting that only serves to make gloom more impressive, and the wonders that may be accomplished at slight expense by employing the waste power of a water wheel. The volume conveys a practical working knowledge of electricity for the production of light, heat, and power. While the water wheel is put forward as an ideally cheap source of power, the windmill and the internal combustion engine are not slighted. The discussion includes such issues as the size of plant required, heating and cooking by electricity, transmission lines, and the operation of the plant. The instruction forestalls almost every possible need of the farmer in his application of electricity to the farm and in the operation of the simple machinery and accessories.

THE CONQUEST OF MOUNT COOK. And Other Climbs. An Account of Four Seasons' Mountaineering on the Southern Alps of New Zealand. By Freda Du Faur. New York: Charles Scribner's Sons, 1915. 8vo.; 250 pp.; illustrated. Price, $4.50 net.

The author's merry account of her earlier attempts at climbing is most entertaining reading, nor does she ever lapse into the pedantic. At the same time there is much of accurate observation and solid information in her work, which should at least commend it to the modest extent of her own wishes—that it may serve as an inspiration for some New Zealander with more material at his command to write more comprehensively of New Zealand mountaineering. Her introductory chapter is a *resume* of the climbing accomplished in the Mount Cook district between 1862 and 1909. The difficulty of obtaining details occasionally reduces this summary to a mere skeleton. Modest as the author's mode of narration is, one can but stand amazed at the physical endurance and pertinacity of will that enabled a representative of the frailer sex eventually to conquer the fastnesses of such a pile as Mount Cook. The numerous illustrations give clear, delightful glimpses of the serrate panorama of the district.

THE YELLOWSTONE NATIONAL PARK. Historical and Descriptive. By Hiram Martin Chittenden, Brigadier-General United States Army (Ret.). Cincinnati: Stewart & Kidd Company, 1915. 8vo.; 350 pp.; illustrated. Price, $1.50 net.

As the officer in charge of road construction, Brigadier-General Chittenden had an excellent opportunity of learning the Yellowstone in all its wonderful aspects. His work included the laying out of some four hundred miles of mountain roads; and the charm of mountain life, the lure of forest trails, and the surpassing grandeur which Nature has lavished upon this region, permeates to no small degree the pages of his volume. He sketches the early days of the *Mi tsi a da zi*, or *Pierre Jaune*, when Crow, Blackfoot and Bannock occupied the country, and the rival fur companies fought their historic battle, through the days of Coulter, Bridger, and other celebrated pioneers, with stories of the gold hunter and chronicles of the various exploratory expeditions. The boundaries and topography of the Park, its flora and fauna, its geological history and its natural marvels, are set forth in an orderly manner, and the administration of Park affairs of course occupies a position of prominence. A large folding map adds to the value and interest of the work. While its appeal to the general reader is undeniable, it also carries a wealth of detailed information not to be found in the books of the tourist-authors. An appendix tabulates the ranges and hills, the lakes, streams, waterfalls and geysers, and these are easily located upon the map by means of marginal references.

BODILY CHANGES IN PAIN, HUNGER, FEAR AND RAGE. An Account of Recent Researches into the Function of Emotional Excitement. By Walter B. Cannon. New York: D. Appleton & Co., 1915. 8vo.; 311 pp.; illustrated. Price, $2 net.

For several years the Harvard Physiological Laboratory has been engaged in a most interesting series of investigations. We are all familiar with the superficial phenomena of the primitive emotions—the facial contortions, the general muscular contractions. Almost as well-known an accompaniment of these states is the increase of available physical strength. Much deeper disturbances are revealed by Prof. Cannon and his collaborators. In his review of earlier European experiments and of his own recent investigations, the author clearly proves the drastic effects of pain, fear and rage upon the digestive system, to the extent of checking secretion of the gastric juice and interfering with the pancreatic secretion and the flow of bile. Thus all the natural processes for producing chemical change in the food may be perverted. Further, these researches disclose a remarkable increase of sugar in the blood. Diabetes and glycosuria are not infrequently traceable to an emotional origin. All these and other fundamental changes are discussed in their relation to increased muscular power and the fighting instinct. Modern warfare is condemned as inadequate to furnish a natural outlet for these emotional energies, and other ways of satisfying these instincts are suggested. The work is an incursion into a much-neglected field that promises to assume great importance in the future.

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